LIFESTYLE AND ENVIRONMENTAL RISK FACTORS ASSOCIATED WITH OVERWEIGHT/OBESITY IN WHITE WOMEN FROM THE LEJWELEPUTSWA DISTRICT, SOUTH AFRICA

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DECLARATION

I declare that the dissertation hereby submitted by me for the Magister degree at the University of the Free State is my own independent work and has not previously been submitted by me to another university/faculty. I further cede copyright of this research report in favor of the University of the Free State.

Ilze Lyell

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Summary

The aim of this study was to describe the lifestyle and the profile of known environmental risk factors for overweight/obesity that exist among the white women of the Lejweleputswa district in the Free State province of SA.

Opsomming

Die doel van hierdie studie was om die leefstyl- en profiel van bekende omgewingsrisikofaktore vir oormassa/vetsug te bespreek wat voorkom tussen die blanke vroue van die Lejweleputswa distrik in die Vrystaat provinsie van Suid-Afrika.

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ADA American Dietetic Association

AI Adequate intake

CHAPTER 1:

ORIENTATION TO, AND MOTIVATION FOR THE STUDY

1.1 Introduction

Overweight/obesity is a global problem, characterised by excess accumulation of adipose tissue which has adverse effects on health and longevity (Zhao, 2011:131; Taylor *et al*., 2010:327; ADA, 2009:330). Cross-sectional and prospective studies have shown that overweight/obesity increases the risk for non-communicable diseases (NCD), including coronary heart disease, hypertension, stroke, type 2 diabetes mellitus, gallbladder disease, infertility, sleep apnoea, hormonal cancers, and osteoarthritis, and that the degree of these diseases tend to worsen as the degree of obesity increases (Lysen & Isreal, 2012:470). According to the World Health Organisation (WHO), worldwide at least 2.8 million people die each year as a result of being overweight/obese (WHO, 2014: Online).

For the first time in history, there are now more overweight/obese people in the world than underweight people (Li & Heber, 2012:86). Furthermore, overweight/obese is not primarily a problem of high income (developed) countries anymore, but is steadily increasing in middle to low income (developing) countries, including South Africa (SA) (Shisana *et al*., 2013:9; Goedecke *et al*., 2006; Kruger *et al*., 2005:419; Senekal *et al*., 2003:109). According to the most recent national survey, the South African National Health and Nutrition Examination Survey (SANHANES-1), conducted in 2012, one third of males and two thirds of females were overweight/obese (Shisana *et al*., 2013: 9).

1.2 Indices of overweight/obesity

Obesity is defined as the excessive accumulation of body fat, including total body fat (Silva *et al*., 2013: 102). Body mass index (BMI), which is the ratio of body weight divided by height squared (kg/m^2) (Pasco *et al*., 2012:1), is the most widely used tool to screen for overweight and obesity. The WHO classifies overweight as BMI of 25.0 to 29.9 kg/m^2 (American Dietetic Association (ADA), 2009:331) and obesity as BMI of > 30.0 kg/m^2 (Mitchell *et al*., 2011:717; Bult *et al*., 2008:135). A BMI of > 25.0 kg/m^2 therefore indicates above normal body fatness or overweight/obesity.

BMI measures body weight relative to height and does not take actual body composition into account (Shields, 2009:143). Particularly, BMI does not distinguish

between being overweight due to lean mass, or due to fat accumulation (Silva *et al*, 2013: 102). Studies indicate that abdominal or central obesity, which refers to the accumulation of adipose tissue around the trunk, is particularly associated with metabolic risk (Alberti, *et al*: 1642). The International and Southern African Associations for the Study of Obesity (IASSO and SASSO, respectively) therefore recommends that the diagnosis of overweight or obesity, and the associated risk for NCDs, should be based on BMI in combination with waist circumference (WC) (SASSO, 2003). BAI. WC is determined in a region where the muscles stabilise the trunk. Therefore, a greater waist size, particularly at the level of the lumbar spine, is almost exclusively attributable, to increased fat accumulation (Silva *et al*, 2013: 102 IASSO and SASSO, in accordance with the WHO, classifies a WC of ≥ 80cm in women and ≥ 94cm in men, as indicating increased risk of NCDs, and a WC ≥ 88cm in women and ≥ 102cm in men as indicating substantially increased risk of NCDs (SASSO, 2003: online). More recently, specific cut off points for WC has been recommended for different ethnic groups. For sub Sahara Africa the International Diabetes Federation recommends 80cm and 94cm as cut-offs for women and men, respectively (Alberti *et al*, 2009: 1642).

Other indexes of increased risk for NCDs based on fat accumulation around the trunk, are waist-hip ratio (WHR) (WC divided by the hip circumference), and waist-to-height ratio (WHtR). Recently body adiposity index (BAI) (% body fat = hip circumference (cm) / Height (m)$^{1.5}$ -18) has also been explored as a direct measure of body fat percentage (Goh *et al.*, 2014:1; Bergman *et al.*, 2011:1083; Sayeed *et al.*, 2003:2).

Waist-to-height ratio is an index of abdominal obesity, able to detect several cardiometabolic risk factors. It is the waist circumference (in cm) divided by the height (in cm). The result should be $\geq$ 0.5 In order to be healthy (Savva *et al.*, 2013:404). This cutoff is used to support the simple health message “keep your waist circumference to less than half your height”.

1.3 Overweight/obesity among South African women

In middle and low income (developing) countries overweight/obesity rates are typically higher among women than men, whereas in high income (developed) countries the ratio is closer to equal or even reversed (WHO, 2014: Online; Kanter & Cabalerro, 2012: 492). This is also true in South Africa, where twice as many women as men are currently overweight/obese, as indicated by SANHANES-1 (Shisana *et al.*, 2013: 9). According Kanter & Cabelerro (2012:495) ‘the topic of gender disparities in obesity remains largely under researched, let alone addressed’. Further research into the factors that contribute to the high prevalence of

overweight/obesity among females in developing countries is thus recommended (Kanter & Cabalerro, 2012: 496).

In 2003, the South African Demographic and Health Survey (SADHS) (2007:279) found that, based on BMI, 28% of SA women over the age of 15 years were overweight, and 27% were obese; indicating that 55% had above normal weight status. In SANHANES-1, conducted in 2012, the prevalence of overweight among SA women was 25%, while the prevalence of obesity had increased to 40.1% (Shisana *et al*., 2013:9); indicating that 65.1% of SA women had above normal weight status.

Similarly, the mean WC for SA women in the SADHS of 2003 was 82.7cm (SADHS, 2007:280) and in SANHANES-1 of 2012, it was markedly higher at 89.0cm (Shisana *et al*., 2013: 9). In SANHANES-1, 50.5% of women had a WC of ≥ 88cm (Shisana *et al*., 2013:10), indicating high risk for NCDs (SASSO, 2003: online); while the mean WHR for women was 0.86 and the prevalence of an increased WHR (≥ 0.85) in women was 47.4% (seven times higher than in men) (Shisana *et al*., 2013:10). This is a marked increase from 2003 when the SADHS found that 32% of SA women had an increased WHR, putting them at risk for NCDs (SADHS, 2007:282)

In 2000 already, NCDs, associated with a high BMI, accounted for 37% of all deaths in SA, according to the SA National Burden of Disease Study (Bradshaw *et al*., 2003:29), emphasising the impact of overweight/obesity in the SA context.

1.4 Risk factors for overweight/obesity

Although weight gain occurs primarily as a result of an imbalance between energy intake (from food/beverages consumed) and energy expenditure (as physical activity) (Lysen & Israel, 2012:465), the aetiology for overweight/obesity is very complex. Primary causes, which directly influences weight gain, can be characterised as either genetic or environmental (diet, physical activity, and socio-behavioural) factors (Lysen & Israel, 2012:467; ADA, 2009:330; Shields, 2009:142). Secondary causes of overweight/obesity include endocrine or central nervous system disorders; side-effects of medications; eating disorders, including binge-eating disorders (BED) and bulimia nervosa (BN); stress; smoking cessation; and virus infections (Schwiertz *et al*., 2009:190).

Studies with twins confirmed that genes determine 50% to 70% of the predisposition to overweight/obesity. Lifestyle and environmental factors are however responsible for activating or deactivating genes that trigger overweight/obesity (Lysen & Israel, 2012:467). There have only been a limited number of identified cases where overweight/obesity was directly caused by a single gene mutation (ADA, 2009: 330).

Environment and lifestyle contribute greatly to the problem of overweight/obesity. Environmental factors, in this context, refer to factors that can be modified by lifestyle changes, including diet, physical activity levels, and psychosocial factors. Modern day social and physical environments are particularly conducive to unhealthy food and beverage choices, and sedentary lifestyles (The New Mexico [NM] Plan to Promote Healthier Weight 2006 – 2015: online). Under these circumstances the majority of normal weight individuals can expect to become overweight/obese, unless they take action to maintain a healthy weight (The NM Plan to Promote Healthier Weight 2006 – 2015).

The realisation that the environment may be facilitating overweight/obesity has increased interest in modifying the environment to help prevent and address the overweight/obesity epidemic. According to Kruger *et al.* (2005:491), possible interventions to prevent and treat overweight/obesity should focus primarily on environmental factors to promote and support behavioural change. Although research in this area is only still emerging, it represents an exciting new approach to the treatment of overweight/obesity (Mitchell *et al.*, 2011:725).

In order to change the environment, more information regarding the lifestyles of overweight/obese women is needed. Overweight/obesity is often addressed as the main problem and treated with diet therapy only, while in fact, sometimes it is a symptom (or result) of another underlying problem (e.g. psychological).

Friedman and Bownell (1995:4) were among the first to suggest that not just eating, but risk factors in multiple domains, may act independently and/or interdependently to contribute to the development of overweight/obesity. Associated factors that have been identified as playing a role in the etiology of overweight/obesity, include decreased physical activity (Amigo & Fernández, 2007:321; Ali & Lindström, 2005:327), television (TV) watching (Inoue *et al.*, 2012:50), sleeping patterns (Chaput *et al.*, 2009:1964), religious service attendance (Ayers *et al.*, 2010:563), emotions (Blair, Lewis & Booth,1990:151), depression (Zhao *et al.*, 2011:130) and addictive behaviour (Gearhardt, Corbin, & Brownell, 2009:432).

In a randomised controlled trail conducted by Gorin *et al.* (2011:618) among overweight (n=201) and normal weight (n=213) adults in America, home environments of overweight/obese adults were found to contain fewer exercise equipment, less low-fat snacks and vegetables and fruit, and more television sets, high fat snacks, and spreads, than those of normal-weight adults. In a cross-sectional (n=537) and longitudinal (n=283) study among overweight and obese American adults (aged 18–64 years) in the Quebec Family Study (QFS), Chaput *et al.* (2009:1965) similarly found that overweight/obese adults had high dietary fat intakes, low dairy, vegetables and fruit intakes, and low levels of physical activity. Therefore, when treating overweight/obesity, interventions with both a dietary and a

physical activity component are expected to result in better weight loss (Wu *et al.*, 2009:313).

1.4.1 Dietary factors

Several dietary factors play a role in the development of overweight/obesity. These include the number of eating occasions (meals and snacks); as well as where food is consumed, i.e., at home, in restaurants or at a fast food establishment (Kolodinsky & Goldstein, 2011:2327). Preparing food and eating at home is associated with better weight control, as studies indicate that a decrease in the number of meals prepared “from scratch”, increases the probability of being overweight (Kolodinsky & Goldstein, 2011:2327).

Another dietary factor that contributes to overweight/obesity, is the increased consumption of energy-dense, nutrient-poor foods containing high levels of sugar and saturated fats (Schwiertz *et al.*, 2009:190). The intake of energy-dense food is known as passive overeating. Active overeating, on the other hand, is defined as partly the result of excessive portion sizes that have become the accepted norm. The portions and energy-content of a single meal from most restaurants and fast food-outlets, often exceed a person’s energy needs for the entire day (Lysen & Israel, 2012:469). Almost half (48%) of South Africans reported that they ever ate outside the home (Shisana *et al.*, 2013:14) – almost a third (28.3%).on a weekly basis and another third (28.7%) on a monthly basis.

According to Shisana *et al.* (2013:13), South Africans living in urban areas had significantly higher fat intakes than those living in rural areas. It was also observed that white South African ate more fat than black or Indian South Africans (Shisana *et al.*, 2013:13). Studies have shown that excessive fat and protein consumption predict a higher BMI, while increased dietary fibre intake, predicts a lower BMI. Similarly, a higher consumption of meat, poultry, and fish has been related to excess weight, whereas increased vegetable and fruit intake has been found to be inversely associated with excess weight (Maskarinec *et al.*, 2006:717). It has been hypothesised that dietary fibre may have a beneficial effect on weight control, by decreasing the overall energy density of the diet and the net amount of energy absorbed (Maskarinec *et al.*, 2006:724). The water and fibre in vegetables and fruits make it naturally low in energy, but satisfying to consume. A diet that includes five to nine or more servings of vegetables and fruits per day, is associated with lower rates of obesity (The NM Plan to Promote Healthier Weight 2006 – 2015).

High intakes of sugar may contribute to micronutrient dilution (a decrease in micronutrient intake relative to total energy intake) (MacIntyre *et al.*, 2012:122). Despite higher energy intakes, micronutrient intakes are not optimal in the SA population, as reflected by deficient intakes of iron, folate, ascorbic acid, and calcium

(MacIntyre *et al*., 2012:128). The WHO now recommends that sugar intake should not exceed 55 g per day, or six to ten per cent of total energy intake (MacIntyre *et al*., 2012:124). Soft drinks, sugar and sweets are more likely to have a negative impact on dietary quality, whereas dairy foods, milk drinks and pre-sweetened fortified breakfast cereals, may have a positive impact due to nutrient density (MacIntyre *et al*., 2012:129).

Chronic overeating "switches on" inflammation in the body, leading to weight gain and insulin resistance (Lysen & Israel, 2012:469); but simple diet and lifestyle changes have been shown to alter obesity-related inflammation. Certain food components such as antioxidants and omega-3 polyunsaturated fatty acid, decrease the intensity of the inflammatory process. Therefore, foods such as oranges are anti-inflammatory, whereas cream may be pro-inflammatory, and red wine neutral. (Lysen & Israel, 2012:469).

1.4.2 Physical activity and sedentary behaviour

Lack of exercise and a generally sedentary lifestyle, compounded by chronic overeating, are primary causes of weight gain. Regular physical activity is critical to overall physical and mental health, physical fitness, and to achieving and maintaining a healthy body weight. It is essential to the development of strong bones, muscles, and cardiovascular health in children, and to maintain that foundation in adults and older adults (The NM Plan to Promote Healthier Weight 2006 – 2015). Physical activity also serves as a protective factor against depression, which is a common problem related to overweight/obesity (Schneider *et al*., 2012: 517358). The SADHS of 2003 (2007:291) found that 63% of South African women were inactive. In 2013 that percentage decreased to 45.2% (Shisana *et al*., 2013:9).

Under normal circumstances physical activity accounts for 15% to 30% of total energy expenditure (Lysen & Israel, 2012:465). The United States Department of Agriculture (USDA) recommends 60 to 90 minutes of intense daily physical activity as the ideal adequate level (Lysen & Israel, 2012:477). There is, however, evidence that, even if an overweight/obese adult is unable to achieve this level of activity, significant health benefits can be realised by participating in at least 30 minutes of daily activity of moderate intensity (Lysen & Israel, 2012:477). Both aerobic and resistance training are recommended.

Time spent watching television (TV) reduces the time spent being physical active. It also increases exposure to advertisements for high-fat, energy dense foods, which may increase snacking, since TV watching is often combined with eating (Shields, 2009:143). It has been found that people exhibit lower resting metabolic rates while watching TV than even while sleeping (Shields, 2009:143), suggesting that a person may burn more energy while sleeping than watching TV. In a sample of older adults,

spending less time watching TV, which is a predominant sedentary behaviour, was associated with lower risk of being overweight/obese, independent of meeting physical activity guidelines (Inoue *et al.*, 2012:50). TV watching for longer than 840 minutes per week has been defined as a risk factor for overweight/obesity (Inoue *et al.*, 2012:51).

Several studies support the finding that each hour of additional TV watching time corresponds to a two to six per cent increase in a child's likelihood of being overweight/obese (The NM Plan to Promote Healthier Weight 2006 – 2015). The American Academy of Paediatrics, together with the TV-Turnoff Network, an organization that encourages children and adults to watch less TV in order to promote healthier lives and communities, recommends no screen time for children under two years of age, as well as limiting older children's screen time to no more than two hours daily (The NM Plan to Promote Healthier Weight 2006 – 2015). For adults a relatively active lifestyle in this context, may be defined as < 10 hours/week of TV watching and ≥ 30 minutes/day brisk walking (Hu *et al.*, 2012:1790).

1.4.3 Smoking

Smoking is associated with lower body weights in adult women, therefore many women believe that smoking will curb their appetite and help them stay thin or lose weight. Smokers also often do not want to quit because of the fear of gaining weight. Studies show that during the first year of quitting smoking, about 4.5 kg of weight is gained. However, a comparison of the diets of smokers and non-smokers found that smokers had higher intakes of total and saturated fat, and consumed fewer fruits and vegetables, and therefore less fibre than non-smokers (Smolin & Grosvenor, 2008:626), putting them at increased health risk. In South Africa 20.8% of the total population (men and women of all ages) smoke tobacco (Shisana *et al.*, 2013:6), at an average of 8.5 cigarettes per day (Shisana *et al.*, 2013:7).

1.4.4 Alcohol consumption

Alcohol accounts for 5.6% of the energy intake in the average US diet. Habitual consumption of alcohol in excess of energy needs, favours lipid storage and weight gain, and thus contributes to obesity and overweight (Janssen *et al.*, 2001:225). According to Breslow (2005: online), the BMI of individuals who drink alcohol may be related to the frequency and quantity of alcohol consumed. Breslow (2005: online) observed that women who drank the smallest quantity of alcohol (one drink/unit per drinking day) with the greatest frequency (three to seven days per week) had a lower BMI than those who infrequently consumed the greatest quantities. One tenth (9.3%) of South African adult women (18 years and up) reportedly consume alcohol (Shisana *et al.*, 2013:10).

1.4.5 Sleep

Short sleep duration is another factor independently associated with overweight/obesity (Chaput *et al.*, 2009:1965; Patel & Hu, 2008:643). Compared to women who slept seven to 7.9 hours per night; women who slept less than six hours per night on average, had significant greater odds of being overweight/obese (Anic, 2010:447). Shortened sleep alters the endocrine regulation of hunger and appetite. Increased secretion of hormones that affect appetite may promote excessive energy intake. Thus recurrent sleep deprivation can modify the amount, composition, and distribution of food intake and may contribute to the obesity pandemic (Lysen & Israel, 2012:469). Chronic partial sleep deprivation causes feelings of fatigue, which may lead to reduced physical activity, as well as hormonal effects that increase energy intake (Patel & Hu, 2008:643). A link between sleep, disrupted circadian rhythms, genes, and the metabolic syndrome, has also been reported (Lysen & Israel, 2012:469).

According to Vorona *et al.* (2005:25) sleeping less than six hours per night, as well as remaining awake beyond midnight, increases the likelihood of overweight/obesity (Vorona *et al.*, 2005:25). In another study, however, sleep duration was not found to be associated with BMI, overweight or obesity in women (Meyer *et al.*, 2011:1280).

1.4.6 Vitamin D status

Low vitamin D status is highly prevalent worldwide. The major determinants of vitamin D status is sun exposure and vitamin D intake (Lukaszuk *et al.*, 2012:229; Palacios *et al.*, 2012:35; Ardawi, 2011:464). Historically, vitamin D deficiency has been more prevalent in the Northern European countries, in homebound elderly individuals, hospitalized patients, and persons with a darker skin colour who have a nutritional deficiency or gastrointestinal malabsorptive conditions (Stratton-Loeffler *et al.*, 2012:498). This perception is changing, as the number of people diagnosed and treated with vitamin D deficiency increases even in the Southern hemisphere. The Institute of Medicine (IOM) (US) has recently increased the recommended daily allowance (RDA) for Vitamin D from 200 to 600 IU for individuals aged 1 – 70 years (Lukaszuk *et al.*, 2012:229). To further complicate the vitamin D dilemma it was found that obesity is associated with increased requirements for vitamin D, or that low vitamin D may even predispose to obesity (Macdonald, 2013:163).

Vitamin D is referred to as the “sunshine” vitamin (Macdonald, 2013:163). Exposure of skin to sun is the only reliable mechanism for the body to synthesise its own vitamin D (Lukaszuk *et al.*, 2012:230). Studies suggest that sunlight accounts for 90% of vitamin D and diet only ten per cent (Macdonald, 2013:163). Vitamin D

occurs naturally in fatty fish, egg yolks, fish liver oils (Lukaszuk *et al.*, 2012:232). Unfortunately these are not foods many people often eat.

Due to concerns about the cancer risks associated with UV radiation from excessive sunlight exposure, advice has been to cover up to avoid sunlight exposure, leading to some groups not getting enough vitamin D. The debate is now on between opposing groups as some evidence indicates that even small amounts of sun may be damaging, while other evidence suggest that with current lifestyles do not allow us to obtain enough vitamin D. A study conducted in the United Kingdom suggests that, in order to make on average 1000 IU vitamin D per day, which represents four times the amount of vitamin D in 100g of oily fish, and should be sufficient to last through the winter months, only one-quarter of the body surface (e.g. the hands, face, and arms) should be exposed to summer sunlight two to three times a week, for up to ten minutes at a time (longer for darker skins), after which the skin should be protected from further sunlight exposure (Macdonald, 2013:163). Another study found that exposing five per cent of the body surface in fair-skinned individuals, two to three times a week, for five minutes at noontime to the summer sun, is equivalent to an intake of 430IU/day of vitamin D (Thieden *et al.*, 2005:1542) which satisfies the recommendation..

To supplement vitamin D may not be as effective as dietary intake or sun exposure, and may even be toxic in high doses (Macdonald, 2013:163).

Serum 25-hydroxivitamin D [25(OH)D] level is the best indicator of vitamin D status (Ardawi, 2011:464) and there is an inverse relationship between 25(OH)D and both BMI and fat mass (Lukaszuk *et al.*, 2012:230). Overweight/obese persons usually have an inadequate vitamin D status (Ardawi, 2011:472; Rodriguez-Rodriguez *et al.*, 2009:778; Thieden *et al.*, 2005:1542). As people receiving low levels of sun exposure may have a vitamin D deficiency (Macdonald *et al.*, 2008:996), this raises the question whether there may be a link between overweight and levels of sun exposure?

Currently no validated, reliable, multi-item vitamin D screening tool exists that is intended for self-administration in community health/wellness settings (Lukaszuk *et al.*, 2012:230) and the assessment of vitamin D [as serum 25(OH)D] requires a blood test.

Although it is clear that sunlight is important for vitamin D synthesis, it remains a challenge to recommend the appropriate sun exposure to produce sufficient vitamin D and minimize skin cancer risk. For those who do not get any sunlight, there continues to be uncertainty about the optimal dose and whether this differs according to population group or geographic location (Macdonald, 2013:163).

1.4.7 Psychosocial factors

One potential means for increasing understanding of the factors required for successful weight maintenance, is to study individuals who have been successful at losing weight and keeping it off. Data from these dieters indicate that they possess coping skills that enable them to respond to cravings or stressful situations in ways that maintain their diets. In a descriptive study by Klem *at al*. (1997:244) improvements occurred in the following areas as a result of weight loss: interactions with same- and opposite-sex friends and strangers, time spent interacting with others, job performance, and participation in hobbies (Klem et al., 1997:244). As boredom is an emotional stimulus to overeating (leading to overweight/obesity) (Hamburger, 1997:164), this raises the question engagement in a hobby can possibly help to prevent obesity.

Studies have also shown that religious activities is associated with good physical health and may be an independent protective factor against overweight and obesity (Dodor, 2012:451; Ayers *et al*., 2010:563; Koenig *et al*., 2001:381). A study among college women found that spiritual well-being was negatively associated with emotional eating and environmental eating (thus preventing overweight/obesity) (Hawks, 2003:30). Koenig *et al. (*2001:381) suggested that religious activities may help participants cope better with stress, and lowers depression, anxiety, and the need for consumption of comfort foods, tobacco, alcohol, or other drugs. Many people attend religious services and belong to religious organizations because they feel it is important to their well-being and helps them feel a stronger connection to their community (Clark, 2000:26). Religious activities help people establish social networks and friendships which contributes to social well-being. Regular attendance at religious services is defined as attending at least once a month (Clark, 2000:23).

Overweight/obesity also creates other social and psychological problems (in turn contributing to even more weight gain). According to Sargent & Blanchflower, (1994:686), overweight/obese women have been found to complete fewer years of school, to have lower incomes, and to be more likely to stay single. Later studies confirmed that overweight/obese individuals are more subject to stigmatisation and prejudice, and are more discriminated against with regard to employment and promotion opportunities (Ali & Lindström, 2005:327; Kruger *et al*., 2005:492), education (Tzotzas, 2010:732), income, and even friendships (Ball *et al*., 2004:1019). Being overweight/obese may also have a lasting effect on women's life satisfaction and their future life aspirations, as they are found to be more dissatisfied with work/career/study, family relationships, partner relationships, and social activities (Ali & Lindström, 2005:327; Ball, Crawford & Kenardy, 2004:1019). In turn, all these problems may lead to more overeating, overweight/obesity; creating a vicious cycle.

Family functioning (as a form of social functioning) is associated with overweight/obesity in childhood (Wen *et al.*, 2011:1252). Family functioning generally refers to interactions with family members that involve physical, emotional, and psychological activities and affects many aspects of family life, including acceptance of individuals, consensus on decisions, communication, and the ability to solve day-to-day problems (Wen *et al.*, 2011:1252). Unhealthy family functioning includes avoiding discussing concerns of fears, having negative feelings within the family, not being able to turn to each other for support or to confide in each other, not being able to talk about sadness or express feelings to each other, having difficulty in making decisions, not accepting family members as they are, and having difficulty in planning family activities (Wen *et al.*, 2011:1253). A mother who has herself experienced poor parenting or an impoverished environment as a child, may in turn have less capacity to influence both healthy family functioning and healthy lifestyle behaviours as an adult (Wen *et al.*, 2011:1256).

Overweight/obese women are at higher risk of poor psychological health (Ali & Lindström, 2005: 327; Ball, Crawford & Kenardy, 2004:1020). Documented theories imply that being overweight/obese is distressing, because it is viewed negatively by society. These negative evaluations are internalized as self-rejection because people view themselves as others see them. Compared to people of normal weight, overweight individuals may suffer from low self-esteem; have negative self-images; and think others dislike them (Ross, 1994:64). Overweight/obesity is therefore associated with high levels of depression (Luppino *et al.*, 2010:220; Zhao *et al.*, 2011:130; Ross, 1994:64). Adults with current depressive symptoms, or with a lifetime diagnosis of depression or anxiety, are more likely to be overweight/obese than adults without either disorder (Luppino *et al.*, 2010:220; Strine *et al.*, 2008:127). Depression is highly comorbid with obesity and may impede weight loss treatment (Schneider *et al.*, 2012:517358). There is some evidence of a relationship between vitamin D and the presence of depression during autumn and winter (Lukaszuk *et al.*, 2012:233). Among overweight/obese individuals, the female gender has been consistently associated with an increased risk of depression, suggesting that overweight/obesity and depression may be linked by gender-specific mechanisms (Ma & Xiao, 2010:347

A person's history of physical, sexual or emotional trauma can also greatly affect weight status for individuals in complicated direct and indirect ways. These factors are included in what are sometime known as 'Adverse Childhood Experiences' (ACEs), and have been studied for their relationship to later risky behaviour, poor health outcome, and the development of numerous chronic conditions, including obesity (The NM Plan to Promote Healthier Weight 2006 – 2015).

Stress can also contribute to obesity (Lysen & Israel, 2012:469) due to cortisol, which is released during stress and stimulates insulin release to maintain blood glucose levels in the "fight-or-flight" response.Overweight/obese individuals report

that stress and depressive symptoms can contribute to unhealthy dietary patterns, which may lead to further weight gain and abdominal obesity (Chambers & Swanson, 2006:79). Eating has been recognised as a coping mechanism for alleviating and dealing with stress and emotions (Schneider *et al.*, 2012:517358; Ozier *et al.*, 2008:49). Furthermore individuals who eat in response to emotions and stress, are more likely to be overweight/obese (Ozier *et al.*, 2008:54; Blair *et al.*,1990:151). Concurrently, individuals who decreased their emotional eating, lost substantially more weight than those who did not decrease their emotional eating (Ozier *et al.*, 2008:54). Therefore it is important to screen for emotional eating, and address the problem, for lifestyle intervention strategies to be successful.

Another way in which depression and stress can contribute to overweight/obesity is through addictive behaviour. Research suggests that eating is commonly used as a method of self-medication in response to negative emotional states, such as depression, anxiety, loneliness, boredom, anger, and interpersonal conflict (Taylor *et al.*, 2010:327). There is increasing agreement that excessive food consumption share many similarities with addictive behaviour (Nijs & Franken, 2012:107) and addiction disorders such as drug/alcohol abuse (Corwin & Grigson, 2009:618; Pelchat, 2009:620; Gibson, 2006:53). This is partly due to the fact that overeating activates the same brain reward mechanisms as other addictive behaviour (Davis, 2009:549), so that highly palatable foods may produce pleasure and reduce pain in a manner similar to other addictive substances (Taylor *et al.*, 2010:327). Unfortunately both food and drugs induce tolerance over time, whereby increasing amounts are needed to reach and maintain intoxication or satiety (Taylor *et al.*, 2010:327). Furthermore, the reward system implicated in drug addiction (Nijs & Franken, 2012:106), may play a role in overeating. Similar to addiction, the attention bias to rewarding foods might play an important role in the development and maintenance of overeating behaviour and weight gain/obesity (Nijs & Franken, 2012:107). Unfortunately the generally high-fat/high-sugar foods associated with Westernized environments are abundantly available, highly rewarding, and advertised aggressively (Nijs & Franken, 2012:106).

1.4.8 Ethnicity

While the abovementioned lifestyle and environmental factors may therefore contribute to the growing global obesity pandemic (Mitchell *et al.*, 2011:717), studies also suggest that not only does the pathogenesis of metabolic and anthropometric differences that accompany overweight/obesity (Kruger *et al.*, 2005:491) vary significantly across different ethnic groups, but also the environmental factors that are relevant to each ethnic group. Therefore, intervention models and materials developed in Western societies, or for use with one particular ethnic group, may not be appropriate in developing countries for those with different lifestyles, habits, and practices.

1.5 Problem statement

There is growing recognition that healthy lifestyles, including healthy body weight, cannot be achieved until the environment that supports unhealthy lifestyles is addressed (Mitchell *et al.*, 2011:728). This is particularly challenging in a country like SA, which includes a great variety of different ethnocultural groups (Valchev *et al.*, 2013:365). The need exists to develop and test culturally appropriate intervention programmes for specific target groups and situations in SA (Senekal *et al.*, 2003:109). In order to achieve this, it is vital to first gain a better understanding of the environmental factors associated with overweight/obesity in the different SA ethnic groups. Such information may aid in the development of more effective weight-loss and weight-control interventions (Goh *et al.*, 2014:1; Shisana *et al.*, 2013:15; Lindberg *et al.*, 2012:2).

Although several studies have investigated culturally specific environmental factors in the black SA population (MacIntyre *et al.*, 2012; Puoane *et al.*, 2002) and among student groups (Senekal *et al.*, 2003), no such studies have been undertaken among white SA women, especially in the rural context. According to the SADHS (2007:279) 55% of SA women over the age of 15 years were overweight/obese; and according to the SANHANES-1 (2013:9) it is 65.1%. The high prevalence of overweight/obesity among white SA women and the lack of information regarding the risk factors for overweight/obesity specifically in this ethnic group, has motivated the current study.SA is subdivided into nine provinces and had a total population of 51.8 million people in 2011 (STATS SA) The Free State Province is situated in the centre of SA and includes approximately 30 000 farms, and produces 41% of South Africa's maize (Department of Agriculture, Forestry and Fisheries, 2014:9). Maize is the most important crop in South Africa, being both the feed grain and the staple food of the majority of the South African population. The rural Lejweleputswa district is situated in the north-western part of the Free State and makes up 24.3% of the province. The district consists of five local municipalities with 18 towns distributed within the municipalities as follows (Lejweleputswa District Municipality, 2010: Online):

Masilonyana: Theunissen, Brandfort, Winburg, Soutpan, and Verkeerdevlei;
Matjabeng:Welkom, Virginia, Odendaalsrus, Hennenman, Ventersburg and Allanridge;
Nala: Bothaville and Wesselsbron;
Tokologo: Boshoff, Dealesville and Hertzogville; and
Tswelepele: Bultfontein and Hoopstad.

There are approximately 56 640 white people living in the Lejweleputsa district, which constitutes 8.6% of the total Lejweleputswa population (census 2001, STATS SA).

This study endeavoured to describe the lifestyle and environmental risk factors for overweight/obesity which occur among white women in this rural part of South Africa. This information will assist dieticians and other health care professionals to gain a better understanding of the factors associated with overweight/obesity among white SA women in a rural area, in order to design appropriate intervention strategies aimed at this ethnic group.

1.6 Aim

The aim of this study was to describe the lifestyle and the profile of known environmental risk factors for overweight/obesity that exist among the white women of the Lejweleputswa district in the Free State province of SA.

1.7 Objectives

In order to achieve the aim, the following objectives needed to be determined:

1.7.1 Socio-demographics (age, district of residence, marital status, occupation, and level of education);
1.7.2 Anthropometry (BMI, BAI, WC, WHR, and WHtR);
1.7.3 Dietary intake (usual daily intake, and meal frequency);
1.7.4 Lifestyle factors (physical activity levels, television-watching, smoking, alcohol consumption); and
1.7.5 Socio-behavioural factors (sleeping patterns, sun light exposure, participation in hobbies, religious service attendance, social functioning, emotional eating, depression, and addictive eating behaviour).

1.8 Layout of dissertation

This dissertation is divided into six chapters:

Chapter 1:

Relevant background information, motivation for the study, and the aim and objectives are described in this chapter.

Chapter 2:

The literature review discusses the prevalence, diagnosis, aetiology, pathophysiology, health consequences (morbidity and mortality) and the management of overweight/obesity, particularly in relation to women and ethnicity.

Chapter 3:

Methods used to conduct the study are described in this chapter. The operational definitions; sampling and study procedure; and selection of techniques to ensure validity and reliability, are discussed. The pilot study and the statistical analysis of the results are described. Practical problems experienced while conducting the study and how these problems were overcome, are also discussed.

Chapter 4:

The results of the study are described.

Chapter 5:

The results of the study are interpreted and discussed in the context of the current body of evidence on the subject of overweight/obesity among white women in South Africa.

Chapter 6:

The conclusions drawn from the results of the study are set out in this chapter. Recommendations regarding the prevention and management of overweight/obesity among white women from the Lejweleputswa district; and recommendations for further research, are discussed.

Chapter 2:

LITERATURE REVIEW

2.1 Introduction

Overweight/obesity refers to the body's level of adiposity (ADA, 2009:330) which adversely affects health and longevity (Zhao, 2011:131; Taylor *et al*., 2010:327). The International Obesity Task Force (IOTF) and the WHO have declared obesity as the epidemic of the 21st century due to the dimensions acquired within the last few decades, the impact on morbidity and mortality and quality of life, and related healthcare costs (Serra-Majem & Bautista-Castaño, 2013:33). This gave rise to the term "globesity". According to the WHO (2014:online) more than one billion people in the world are overweight/obese, that is more than the number of underweight people (Li & Heber, 2012:86) Dieticians play an important role in addressing this epidemic by giving evidence-based nutrition and lifestyle advice, and helping people to achieve and maintain a healthy weight.

In this chapter the current theories regarding components and regulation of body weight, the prevalence and epidemiology, classification, and etiology of overweight/obesity is discussed.

2.2 Components of body weight

Adipose tissue is the major energy-storing tissue, and has an almost unlimited capacity to expand (Sun *et al*., 2011:2094). Adipose tissue consists of adipocytes (fat cells), which contains a single large lipid droplet. The number of adipocytes varies from one type of connective tissue to another, from one region of the body to another, and from person to person (Trujillo & Scherer, 2006:763). The total fat mass in the body is divided into essential fat and storage fat. Essential fat is necessary for normal physiological functions, and is stored in small amounts in the bone marrow and in some organs (Lokuruka, 2013:7093). Storage fat accumulates under the skin and around internal organs (Thomas *et al*., 2012:76).

2.2.1 Adipose tissue size and distribution

Adipose tissue can increase in size via two distinct mechanisms, namely hypertrophy, which refers to an increase in adipocyte volume, and hyperplasia,

which refers to an increase in adipocyte cell number (Sun, Kusminski & Scherer, 2011:2094). Hyperplasia occurs as a normal growth process during infancy and adolescence, where cell number increase in both lean and obese children into adolescence (but the number increases faster in obese children). Hypertrophy can occur at any age, where fat depots can expand as much as 1000 times. With weight loss, fat cell size decrease but cell numbers remain the same (Israel & Lysen, 2012:464).

Although it is recognised that adipocyte hypertrophy prevails in obesity, some debate remains as to whether the adipocyte number stays constant in an adult individual, and whether the ability to undergo hyperplasia is age dependent (Sun, Kusminski & Scherer, 2011:2094).

Two distinct types of adipose tissue also occur in the body, namely white adipose tissue and brown adipose tissue. White adipose tissue function to store excess energy as triglycerides. Brown adipose tissue is more prevalent in infants, making up 5% of body fat. Brown adipose tissue is found on the back, along the upper half of the spine, and toward the shoulders; mainly to avoid hypothermia (Ohno *et al.*, 2012:395). Brown adipose tissue also has a potential role in the defense against obesity and obesity-associated disorders, and therefore the developmental and transcriptional control of brown adipose tissue has received much attention over the last several years (Ohno *et al.*, 2012:395). Two different types of brown adipocytes have been identified, with and without the muscle factor Myf5 (Ohno *et al.*, 2012:395). They both derive from pericytes, the cells which surrounds the blood vessels that run through the white adipose tissue.

Obesity is characterised by the accumulation of excess lipids in white adipose tissue. Further distinction is made between healthy fat distribution and pathological fat distribution. Healthy fat distribution (Figure 1, A) occurs when adipocyte precursor cells differentiate into small adipocytes, along with the recruitment of other stromal cell types in appropriate ratios with good vascularization (Sun *et al.*, 2011:2096). In contrast, pathological fat distribution (B) can be described by a rapid growth of the fat pad through enlargement of existing fat cells, a high degree of macrophage infiltration, limited vessel development, and massive fibrosis (the formation of excess fibrous connective tissue) . Such pathological expansion is associated with chronic inflammation, which ultimately results in the development of systemic insulin resistance (Sun *et al.*, 2011:2096).

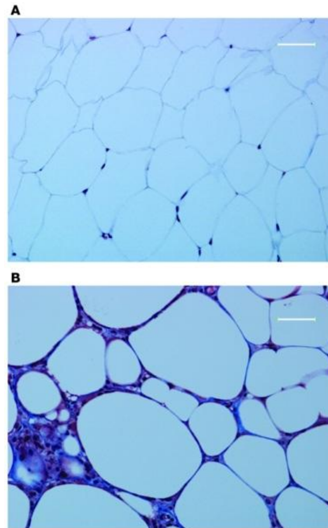

Figure 1: Healthy fat distribution (A) and pathological fat distribution (B) (Sun *et al.*, 2011:2097).

White adipose tissue represents a specialised type of connective tissue, composed of a number of different cell types, each with specific functions, and may be roughly divided in two fractions, namely the adipocyte fraction and the stroma vascular fraction (Stryjecki & Mutch, 2011:1).

2.2.2 Metabolic activity of adipose tissue

White adipose tissue, in both storage and essential fat components, is not just a passive reservoir for storing lipids, but metabolically active endocrine organ. Both the adipocyte fraction and stroma vascular fraction secrete molecules, referred to as adipokines, which regulates energy metabolism, insulin sensitivity and inflammation. Obesity is characterised by low grade inflammation caused by dysregulation of some adipokines, such as tumor necrosis factor-alpha (TNF-a), interleukin-6 (IL-6) and adiponectin (Lokuruka, 2013:7093; Stryjecki & Mutch, 2011:285). Over 100 adipokines have been identified and more adipokines continue to be discovered (Enns *et al*, 2011:online).

White adipose tissue is distributed in the body as subcutaneous fat (under the skin) and visceral (intra-abdominal) fat (Macotela *et al.*, 2012:1691), which differ regarding including levels of adipokine secretion, insulin sensitivity, lipolysis (the breakdown of lipids for energy) rate, and tendency to develop inflammation (Macotela *et al.*, 2012:1691). Subcutaneous fat expands more by hyperplasia, and visceral fat expands by hypertrophy (Macotela *et al.*, 2012:1698).

Human studies have indicated a possible protective metabolic role for subcutaneous fat. (Macotela *et al.*, 2012:1691). Subcutaneous fat in the legs, for example, is associated with decreased risk of impaired glucose and lipid metabolism (Thomas *et al.*, 2012:76). Visceral fat is associated with fat deposition in the intra-abdominal cavity, causing the so-called "apple figure" (Figure 2). This is referred to as abdominal obesity (Figure 2), and is associated with adverse metabolic outcomes, including elevated plasma low-density lipoprotein (LDL) cholesterol, and appears to

play a major role in the pathogenesis of insulin resistance, diabetes, dyslipidaemia, inflammation, and hypertension (Lokuruka, 2013:7093; Thomas *et al.*, 2012:76).

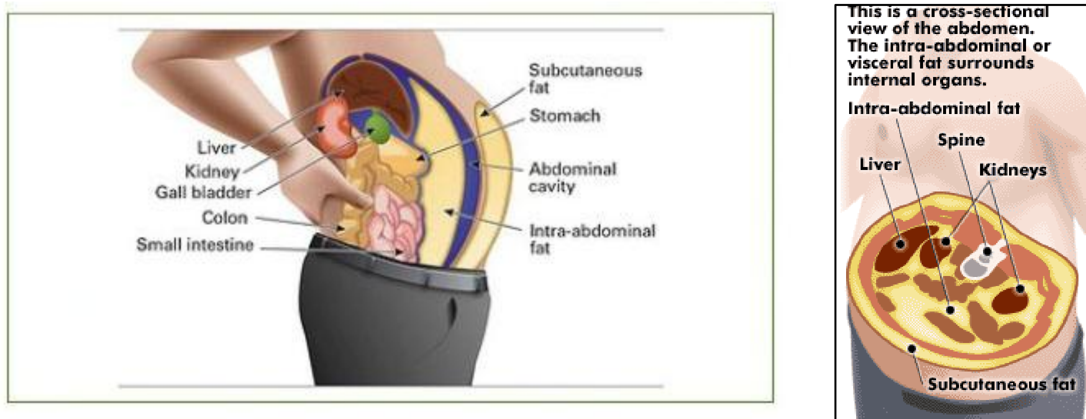

Figure 2: Visceral (intra-abdominal fat)
(http://usatoday30.usatoday.com/news/health/2003-02-25-bellyfat-usat_x.htm; https://betternutrition4all.wordpress.com/2011/06/13/)

2.3 Regulation of body weight

Adipose tissue responds rapidly to alterations in macronutrient deprivation and excess. Rodent models are used to study processes that are important for the remodeling of adipose tissue in humans. This holds the added advantage that adipose tissue in rodent models expand and reduce at an extremely rapid rate. A 24-hour fast in a mouse causes dramatic loss of adipose tissue mass and stimulates an acute remodeling process characterised by rapid infiltration of phagocytic cells; on the other hand, just 24 to 48 hours of exposure to a high-fat diet is associated with a prompt increase in adipocyte size (Sun *et al.*, 2011:2094).

2.3.1 The concept of energy balance

The body's energy balance is determined by the amount of energy ingested (in food and drinks) in relation to the amount of energy expended (in metabolism and physical activity). To maintain a stable body weight, energy intake must, over time, exactly equal energy expenditure. All foods and drinks ingested (energy intake) are normally metabolised to maintain a basic metabolic rate, thermogenesis, and muscle action (energy expenditure) (Lenard & Berthoud, 2008: S11). A negative energy balance (in which energy expenditure exceeds energy intake) results in weight loss, whereas a positive energy balance (in which energy intake exceeds energy expenditure) results in weight gain (Serra-Majem & Bautista-Castaño, 2013:39; Mitchell *et al.*, 2011:724; ADA, 2009: 330). Excess energy is stored as fat. Most stored fat comes from fat eaten; but excess carbohydrates and protein can also be

converted to fatty acids in the liver by a process called lipogenesis (Israel & Lysen, 2012:464). Lipoprotein lipase is an enzyme that moves lipid from the blood into the adipose cell where it hydrolyses triglycerides into free fatty acids and glycerol. Glycerol goes to the liver and fatty acids enter the adipocytes, and are reesterified into triglycerides (Israel & Lysen, 2012:464).

2.3.2 Components of energy intake and expenditure

The only contributors to energy intake is food and drink consumption. This is however, affected by multiple factors, including psychological, social, and work-related factors (Garaulet & de Herdia, 2010:9), which will be discussed later.

The components of energy expenditure on the other hand, include basal metabolic rate (BMR), the thermic effect of food (TEF), physical activity, and non-exercise activity thermogenesis (Raymond *et al*., 2012:766; Lenard &Berthoud, 2008:S21). BMR contributes 60 to 75% of daily energy expenditure associated with the maintenance of normal body functions required to sustain life, including breathing, circulation, temperature regulation, hormone secretion, nerve activity and sympathetic nervous system activation (Sizer & Whitney, 2008:323). BMR decreases with age and during restricted energy intake. However, when adequate food intake is restored, the BMR returns to baseline levels (Lysen & Israel, 2012:465).

TEF is the additional energy expenditure above the BMR associated with the processing of food during consumption and storage. The TEF is influenced by meal size and composition, the nature of previous meals, insulin resistance, physical activity and aging (Lysen & Israel, 2012:465).

Physical activity is the most variable component of energy expenditure (Lysen & Israel, 2012:465) and therefore energy intake is better matched to energy expenditure when people are physically active (Serra-Majem & Bautista-Castaño, 2013:40).

With underfeeding and weight loss, total (i.e., 24-hour) energy expenditure, BMR, TEF, and physical activity decrease, whereas increases in energy expenditure and BMR (but not physical activity) are observed in response to overfeeding and weight gain (Müller *et al*., 2010:60).

2.3.3 Mechanisms that regulate energy balance

Neurochemicals, body-fat stores, protein mass, and hormones are all regulatory systems that regulate food intake and body weight. Regulation takes place on both a short- and a long-term basis. Short-term regulation refers to hunger, appetite, and satiety. Satiety is when food is stored after a meal; and hunger refers to the postabsorbtive state when those stores are being mobilised. Hunger can be felt stronger than satiety, contributing to overeating. Long-term regulation occurs when "normal" body composition is disturbed. Adipokines act as signaling molecules. Younger persons are much more responsive to them as older adults (Israel & Lysen, 2012:465).

There is a homeostatic regulation of adiposity and body weight to maintain the energy balance in the body. To correct an energy deficit, energy intake is stimulated and expenditure suppressed. Metabolic signals relating to an energy surplus will do the opposite in triggering other compensatory changes to maintain energy balance (Lenard & Berthoud, 2008:S12).

2.3.3.1 Regulation through neurotransmitters

Regulation of body weight can be divided into neurological and hormonal regulation. The arcuate nucleus (a part of the brain's hypothalamus) is an important centre for integrating nutritionally relevant information (Lenard & Berthoud, 2008:S12). The brain neurotransmitters include norepinephrine, dopamine, and serotonin. Norepinephrine is released by the sympathetic nervous system in response to dietary intake, it then mediates the activity in the brain that governs feeding behaviour (Israel & Lysen, 2012:465). Dopamine increases the motivation for food intake (Heber & Carpenter, 2011:161). Consumption of favourite foods increases dopamine concentrations, reinforcing effects of euphoria and pleasure. The repeated stimulation of this dopamine reward pathway has been proposed to increase compulsive behaviour affecting both food and drug intake (Heber & Carpenter, 2011:161). It has also been shown that obese individuals have reduced levels of dopamine D2 receptors and that these are inversely related to body weight (Heber & Carpenter, 2011:161). The neurotransmitter serotonin has been associated with an increase in carbohydrate appetite (Israel & Lysen, 2012:465).

Another brain neurotransmitter is called ghrelin. Ghrelin is produced by the stomach, and act on the hypothalamus to stimulate hunger and feeding. Ghrelin plays an important role in appetite regulation (Williams & Elmquist, 2012:1351). Ghrelin levels are highest in lean people, and also in people who are dieting (Israel & Lysen, 2012:465). Diet-induced weight loss results in compensatory increase of hunger, cravings, and decreased ghrelin suppression that encourage weight regain. A high protein and carbohydrate breakfast may overcome these compensatory changes and prevent overweight/obesity relapse (Jakubowicz et al., 2012:323).

GABA is a neurotransmitter that is critical in regulating feeding behaviour and/or energy balance, but works outside the hypothalamus (Williams & Elmquist, 2012:1351).

2.3.3.2 Regulation through hormones

Leptin and insulin are gut hormones that regulate energy intake and body weight. Leptin is released by adipocytes in order to reduce food intake (Taghva *et al.*, 2012:225). It was found that mice with fully functioning leptin-producing genes were slim; and that mice that produced insufficient leptin became obese. In obese humans, however, leptin levels are sometimes elevated (Taghva *et al.*, 2012:225) so giving them more of this hormone is not helpful. The regulatory process is very complex and further research is needed.

Insulin acts in the central and peripheral nervous systems to regulate food intake (Israel & Lysen, 2012:466; Williams & Elmquist, 2012:1351). Insulin is also involved in the synthesis and storage of fat. Fasting insulin levels increase with the degree of obesity, and this may be due to insulin resistance (Israel & Lysen, 2012:466). Postprandial insulin levels are more controlled with more frequent meals. Skipping meals (especially breakfast) are associated with higher levels of insulin (Schwarz *et al*., 2011:10).

CCK & GLP-1 are also gut hormones. CCK is released after a meal and suppresses food intake and meal size (Williams & Elmquist, 2012:1351). GLP-1 reduces food intake, increases satiety and promotes weight loss (Williams & Elmquist, 2012:1351).

2.3.4 Set-point theory

Many people appear to keep a constant body weight throughout adult life. Overeating is followed by increases in thermogenesis, whereas increases in energy expenditure (e.g., due to strenuous exercise) affect food intake. The general idea is that human body weight is under sufficiently strong genetic and humoral control, a view inspired by the theory of the so-called 'set point'. The theory proposes a proportional feedback control system designed to regulate body weight to a constant 'body-inherent' weight, namely the set point weight (Müller *et al*., 2010:59). According to this theory, the system adjusts food intake or energy expenditure (or both) in proportion to the difference between the current body weight and the set point weight (Müller *et al*., 2010:59).

However, intervention studies suggest that a set point in humans is 'loose' (e.g., involving upper and lower limits), rather than tightly controlled (Müller *et al*., 2010:60).

2.4 Overweight/obesity

A chronic positive energy balance therefore leads to the accumulation of body fat and eventual overweight/obesity.

2.4.1 Prevalence and epidemiology

Overweight/obesity is a global problem (De Maria, 2013:784; Zhao, 2011:131). In 2010 the WHO estimated that one billion adults worldwide were overweight and about 300 – 400 million were obese (Lokuruka, 2013:7090). In 2011, among Canadian women (18 years and older) the prevalence of overweight and obesity combined was 44.2%, whereas the prevalence of obesity alone was 16.8% (Ramage *et al*., 2014:1). Overweight/obesity is not primarily a problem of high income (developed) countries anymore, but is steadily increasing in middle to low income (developing) countries, including South Africa (SA) (Shisana *et al*., 2013:9; Goedecke *et al*., 2006; Kruger *et al*., 2005:419; Senekal *et al*., 2003:109), China, and India (De Maria, 2013:784). At least 24% of adults in Great Britain are obese, as are more than 20% of adults in countries such as Brazil, and the United Arab Emirates (De Maria, 2013:784). It is likely that overweight/obesity have been a major contributor to the transition from infection to chronic diseases as the predominant cause of death in the developing world (De Maria, 2013:784).

According to the most recent national survey, the South African National Health and Nutrition Examination Survey (SANHANES-1), conducted in 2012, one third of males and two thirds of females were overweight/obese (Shisana *et al*., 2013: 9).

SADHS of 2003 (2007:279) found that 55% of women over the age of 15 years were overweight/obese. Black women (over the age of 15 years) were the worst affected with 27.7% being overweight and 28.5% obese. White women showed similar figures for overweight (24.3%), with a slightly lower occurrence of obesity (13.7%). In 2013, according to the SANHANES-1, the prevalence of overweight in SA women (across all ethnic groups) was 25%, and the prevalence of obesity was 40.1% (Shisana *et al*., 2013:9). Therefore 65.1% of SA women were found to be overweight/obese.

2.4.2 Classification and assessment of overweight/obesity

Overweight/obesity is classified into android type overweight/obesity, gynoid type overweight/obesity, and the third type of overweight/obesity. The android type of obesity is likened to the shape of an apple and associated with visceral or intra-abdominal fat accumulation as discussed above (Figures 2, 4).

In gynoid type obesity the excess fat is stored in the lower part of the body as somewhat flabby flesh in the abdomen, thighs, buttocks and legs, and the body is shaped more like a pear (figure 4). The face and neck mostly has a normal appearance. This type is more common among women.

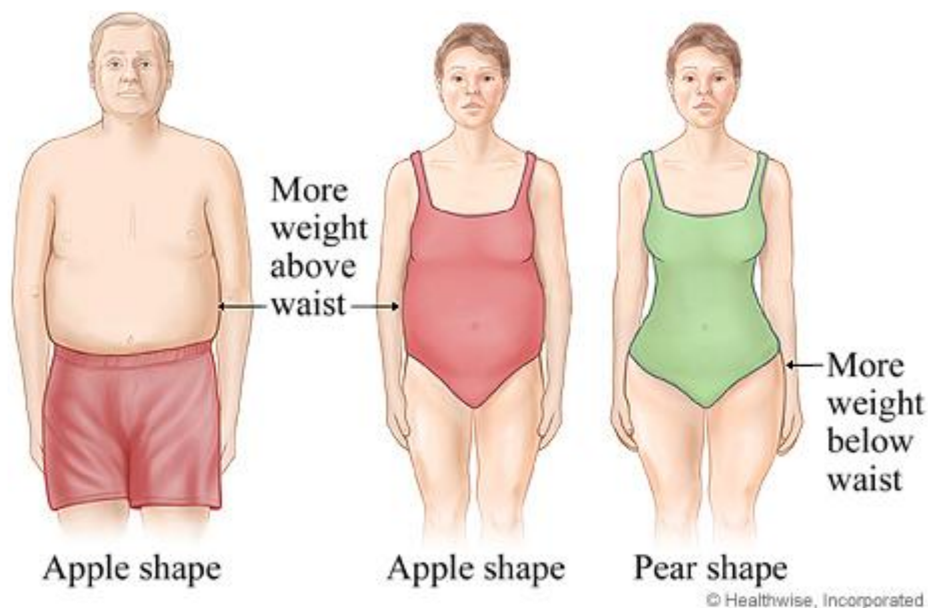

Figure 4: Adroid and gynoid fat distribution

(http://images.emedicinehealth.com/images/healthwise/medical/hw/h9991471_001.jpg)

A third type of overweight/obesity is distinguished in some people who do not fit into either of the above types of obesity. In these cases, the whole body from head to toe resembles a barrel. Any excess fat tissue in the intra-abdominal area, hinder the movement of all the internal organs and consequently affect their brisk functioning (Abdullah & Azman, 2011:57).

Anthropometric assessment provides a fast, inexpensive method of assessing the body composition and size (Gibson, 2005: 10). A person has traditionally been considered to be obese if they weigh more than 20 percent more than their ideal weight (Abdullah & Azman, 2011:57). Current anthropometric methods to diagnose and monitor overweight/obesity, include BMI, BAI, WC, WHR, and WHtR (Aswathappa *et al*., 2014: 1619).

2.4.2.1 BMI

BMI is the most widely used index of excess body fatness (Lichtash *et al*., 2013:e65954). BMI is a simple estimate of fat mass based on the ratio of weight to height squared [weight (kg)/height squared (m^2)] (Pasco *et al*., 2012:1). Overweight is defined as a BMI of 25 to 29, and a BMI above 30 reflects obesity with more excessive amounts of body fat.

BMI correlates with fat mass and other diseases (ADA, 2009:332), lipid parameters, glucose homeostasis traits (Lichtash, 2013:e65957), cardiovascular disease risk (Goh *et al*., 2014: online), and even risk for premature death (Morris, 2011:3).

Unfortunately BMI is a poor descriptor of central adiposity (Aswathappa *et al*., 2014: 1618), and does not take actual body composition into account (Lichtash *et al*., 2013:e65954; Lokuruka, 2013:7090; Shields, 2009:143). A higher BMI does not always reflect increased body fat as excess weight can be due to increased muscle mass, influenced by such factors as sex, age, genetics, exercise, and ethnicity (Geliebter *et al*., 2013:493). Women, for instance, have significantly greater amounts of total body fat than men, and older individuals have significantly greater amounts of total body fat than those who are younger (Lichtash *et al*., 2013:e65954).

2.4.2.2 BAI

Body adiposity index (BAI) presents a method of estimating body fat without requiring assessment of body weight, offering a simple-to-use tool (Lichtash *et al.*, 2013:e65954; Bergman *et al*, 2011: 1038), which, unlike BMI, is equally useful for both genders and for different ethnicities (Geliebter *et al.*, 2013:493). BAI is a direct estimate of percentage body fat and is interpreted according to gender and age appropriate fat percentage cut-off points (Bergman *et al*, 2011: 1083). BAI correlates with cardiovascular risk (Bergman *et al.*, 2011:1083).

BAI is the nonlinear ratio of hip circumference to height (Geliebter *et al.*, 2013:493):

$$\text{BAI (\% body fat)} = \text{hip circumference (cm)} / \text{height (m)}^{1.5} - 18$$

2.4.2.3 WC

WC, measured midway between the top of the superior iliac crest and the lowest rib in the mid axillary line, is a measure of central obesity (Goh *et al.*, 2014:1). Central obesity is associated with the metabolic syndrome, which includes insulin resistance, glucose intolerance, dislipidaemia, hypertension and a prothrombic and pro-inflammatory state (Goedecke *et al.*, 2006:68). WC, WHR, and WHtR are all three parameters of central obesity.

WC has a strong correlation with fat mass and other diseases (ADA, 2009:332) and with visceral fat distribution (Ali & Crowther, 2005:113). WC also has correlations with cardiovascular risk (Goh *et al.*, 2014: online), lipid parameters, glucose homeostasis traits (Lichtash, 2013:e65957).

2.4.2.4 WHR

Waist-hip ratio (WHR) is another central obesity measure, but with a stronger predictive ability than WC and BMI in white women (Goh *et al.*,2014:onine). WHR is correlated with metabolic risk (Ali & Crowther, 2005:113) and cardiovascular risk (Goh *et al*, 2014:online).

WHR is calculated as WC divided by the hip circumference (Goh *et al.*, 2014:1). The National Institute of Diabetes, Digestive and Kidney Diseases (NIDDK) uses a cut-off point of 0.8 (ADA, 2000:16) and the WHO a cut-off point of 0.85, above which increased health risk is implied.

2.4.2.5 WHtR

WHtR identifies people with an increased cardiometabolic risk (Savvas *et al.*, 2013:403) and correlates strongly with cardiovascular risk (Goh *et al.*, 2014:online). WHtR has a stronger association with diabetes than BMI and WHR (Savvas *et al.*, 2013:403). No single index among BMI, WC, WHR, and WHtR is superior than any other in detecting dislipidaemia in both Asian and non-Asian populations (Savvas *et al.*, 2013:403).

WHtR is the waist circumference (in cm) divided by the height (in cm). The answer should be more than (or equal to) 0.5 in order for the waist circumference to be less than half the weight, as recommended (Savvas *et al.*, 2013:403).

At a conference of the Endocrine Society's 96th Annual Meeting and Expo in Chicago (Crawford, 2014) it was discussed that the WHtR performs best as the single indicator of adiposity related to cardiometabolic risk factors across midlife women of diverse racial ethnic backgrounds. The analysis included 2911 women, mean age 46 years, 49% Caucasian, 27% African American, 8% Hispanic American, 8% Chinese American, and 9% Japanese American women.

2.4.3 Health consequences of overweight/obesity

The defining metabolic changes in overweight/obesity are decreased glucose tolerance, decreased sensitivity to insulin, hyperinsulinemia and reduced life expectancy (Lokuruka, 2013:7089). Overweight/obesity is associated with macrophage infiltration and with both hyperplasia and hypertrophy of adipocytes, often leads to a chronic disease state of such patients (Lokuruka, 2013:7095).

Due to the effect of overweight/obesity SA is undergoing a process of epidemiological transition from infectious to non-communicable diseases (NCDs) (Shisana *et al.*, 2013:1).

Obesity results in chronic low-grade inflammation of several organs, including the liver, muscle, and adipose tissue, as well as the hypothalamus (Lee & Ahima, 2012:23). Inflammation is thought to exacerbate metabolic abnormalities by disrupting homeostatic pathways within target tissues (Lee & Ahima, 2012:23).

Inflammation in the hypothalamus is thought to be harmful to neuronal function (Lee & Ahima, 2012:24), little is known about the effects of a high-fat diet on glia – non-neural cells that are more abundant in the central nervous system than neurons, provide support and nutrition to neurons (astrocytes), and mediate inflammation in the brain (microglia). Moreover, it is not clear how closely hypothalamic inflammation mirrors peripheral inflammation (Lee & Ahima, 2012:24).

Overweight/obesity is associated with profound changes in the structure of neurons and glia in the hypothalamus (Lee & Ahima, 2012:24). Much less is known about how overweight/obesity affects the structure of the hypothalamus. In examining the effects of obesity on neurons and glia in the hypothalamus, it gets revealed that obesity may be in part due to hypothalamic injury, which leads to inflammation and reduced neurogenesis. These findings support the notion that obesity is a disease that affects multiple organs, including the brain, and that disruption of normal brain function leads to abnormal regulation of peripheral metabolism (Lee & Ahima, 2012:22).

Obesity alters the normal structure of the arcuate nucleus (Lee & Ahima, 2012:22). Several studies found that the hypothalamus is dynamic in terms of neuronal turnover and glial activation and that the arcuate nucleus is particularly vulnerable to overweight/obesity (Lee & Ahima, 2012:22).

Obesity is associated with suppression of hypothalamic neurogenesis, and increased hypothalamic injury and gliosis (Lee & Ahima, 2012:24).

2.4.3.1 Morbidity

The WHO recognises the impact overweight/obesity has on the development of the most prevalent chronic diseases in modern society, including:

i. Type 2 diabetes mellitus (Serra-Majem & Bautista-Castaño, 2013:33; Ciao *et al.*, 2012:e9; Foster-Schubert *et al.*, 2012:1628; Greenway *et al.*, 2009:30). Many obese patients may be in a pre-diabetic state without even knowing it (Lokuruka, 2013:7095);
ii. Hypertension (Lokuruka, 2013:7096; Ciao *et al.*, 2012:e9; Greenway *et al.*, 2009:30);
iii. Cardiovascular disease (Serra-Majem & Bautista-Castaño, 2013:33; Ciao *et al.*, 2012:e9; Foster-Schubert *et al.*, 2012:1628; Greenway *et al.*, 2009:30);
iv. Coronary Artery Disease (Foster-Schubert *et al.*, 2012:1628; Greenway *et al.*, 2009:30);
v. Stroke (Lokuruka, 2013:7096; Greenway *et al.*, 2009:30);
vi. Heart attack (Lokuruka, 2013:7096);
vii. Congestive heart failure (Lokuruka, 2013:7096);
viii. Certain cancers (Serra-Majem & Bautista-Castaño, 2013:33; Foster-Schubert *et al.*, 2012:1628; Greenway *et al.*, 2009:30), mainly colorectal and prostate cancers (Lokuruka, 2013:7096);
ix. Depression (Greenway *et al.*, 2009:30);
x. Musculoskeletal pathologies (Serra-Majem & Bautista-Castaño, 2013:33); and
xi. Sleep apnea (Lee & Ahima, 2012:22).

Excess adiposity, particularly central adiposity, is a key causal factor in the development of insulin resistance, the hallmark of the condition known as the metabolic syndrome. In addition to abdominal obesity the metabolic syndrome is characterised by dyslipidemia and hypertension, which are associated with increased risk for type-2 diabetes mellitus and CVD (DeMaria, 2013:785; Philips *et al.*, 2013:E154).

Most persons with the metabolic syndrome are obese. An increase in adipose tissue results in elevations of circulating free fatty acids and other adipokines. The latter appear to underlie both a pro-inflammatory state (Stryjecki & Mutch, 2011:1) and a pro-thrombotic state. An increase in free fatty acids induces insulin resistance in muscle, which contributes to an elevation of plasma glucose. In the long run, a high free fatty acids may impair beta-cell function through “lipotoxicity”; this too will promote a higher glucose concentration (Stryjecki & Mutch, 2011:1).

Elevated free fatty acids probably contributes to an increase in hepatic glucose output and worsening hyperglycemia, but in addition, a high free fatty acids underlies an increase in plasma triglycerides (TG), which in turn lowers high-density lipoprotein (HDL) cholesterol levels. Obesity is associated with an increased blood pressure (BP), although the mechanisms for this effect are not well understood. A pro-inflammatory state likely predisposes to pre-diabetes by enhancing insulin resistance. Many investigators also believe that a pro-inflammatory state predisposes to cardiovascular disease, as does a pro-thrombotic state. Although obesity predisposes to both pre-diabetes and metabolic syndrome, various localized defects in specific organs or tissue likely contribute as well (Grundy, 2012:637) (Figure 5):

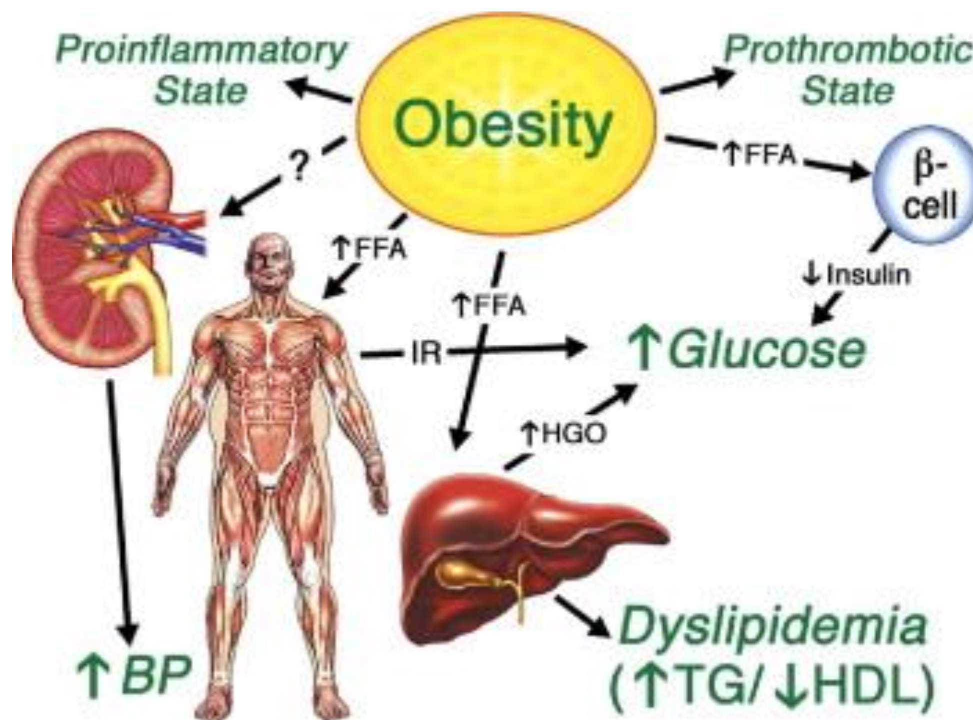

Figure 5: Metabolic pathways underlying pre-diabetes and metabolic syndrome (Grundy, 2012:637):

Inflammation occurring in the white adiposity tissue is general associated with the development of obesity-related co-morbidities such as cardiovascular disease and type 2 diabetes (Stryjecki & Mutch, 2011:2). More specifically, enlarged adipocytes, coupled with macrophage infiltration, result in the increased secretion of pro-inflammatory adipokines that favour lipolysis, leading to ectopic lipid accumulation,

as well as a disruption in glucose and insulin signaling pathways throughout the body (Stryjecki & Mutch, 2011:2). Insufficient use of the muscles of the trunk and limbs of the respiratory system and of the myocardium, increases the risk of orthopedic, respiratory and circulatory disorders (Lokuruka, 2013:7096). Weight reduction regimens have been shown to lower inflammatory markers (Sun *et al.*, 2011:2094). Consumption of a high ratio of omega-6 to omega-3 fatty acids is also an important indicator for a potentially inflammatory profile (Myers & Allen, 2012:14).

Despite women tending to be more overweight/obese than men, they are less prone to hypertension, heart disease and type 2 diabetes than men before they reach menopause, due to their fat deposition being predominantly sub-cutaneous rather than abdominal (Lokuruka, 2013:7089).

2.4.3.2 Mortality

Diverse epidemiological studies describe a direct relationship between BMI and mortality (Serra-Majem & Bautista-Castaño, 2013:33).

Obesity-related morbidity leads to increased use of hospitalization and greater mortality than normal weight adults, making obesity second only to smoking as the leading cause of preventable death (Greenway *et al.*, 2009:30). Obesity is the fifth leading cause of global deaths (Lokuruka, 2013:7090).

Obese patients have an increased risk of death under anesthesia; whereas surgical operations are more difficult, and are often accompanied by post-operative complications (Lokuruka, 2013:7095).

2.4.4 Aetiology of overweight/obesity

Overweight/obesity occurs primarily as a result of an imbalance between food consumed and physical activity (DeMaria, 2013:784; Lysen & Israel, 2012:465). The etiology for overweight/obesity is, however, very complex, and primary and secondary causes are distinguished. Primary causes for overweight/obesity are genetic and environmental (diet, physical activity, and socio-behavioural) factors (Israel & Lysen, 2012:465; ADA, 2009: 330; Shields, 2009:142). Secondary causes include endocrine or central nervous system disorders, side-effects of drugs, binge-eating disorders (BED), bulimia nervosa (BN), high glycemic diets, stress, smoking

cessation, virus infection and possibly due to the interaction between bacteria in the body (Schwiertz *et al.*, 2009:190).

2.4.4.1 Heredity, genetics and intrauterine programming

The tendency to gain weight is not only about our lifestyle choices, but is also embedded in the human genome. Compared to the general population, the risk of becoming obese is on average two to three times higher for an individual with a family history of obesity. It is important to take note that family members not only share similar genes, but they also make similar dietary and lifestyle choices (Junyent *et al.*, 2010:699).

There have, however, been only a limited number of overweight/obesity cases identified as being directly caused by a single gene mutation (ADA, 2009: 330). On genetic level overweight/obesity is an extremely complex problem with many genes that contribute to the condition. In fact, hundreds of genes could be involved in regulating weight, including genes responsible for the control of appetite, generation of fat tissue, metabolism of the food we eat and other aspects of body function. Our current lack of understanding of the numerous gene-gene and gene-environment interactions underlying overweight/obesity poses one of the major obstacles for the development of effective preventative and therapeutic intervention strategies (Stryjecki & Mutch, 2011:1).

Some of the gene-variants associated with overweight/obesity:

i. Two ADAM17 genetic variants (m1254A>G and i33708A>G) are associated with obesity (Junyent *et al.*, 2010:703).
ii. The *FTO* gene is associated with obesity and to influence appetite control (Sonestedt *et al.*, 2009:1418).
iii. Gln27Glu appear to be one of those gene versions that may make dieting difficult.
iv. Women with two copies of one form of the gene, Arg16Arg, responded to an exercise program with a greater loss of body fat, compared with those without this gene variant.
v. UCP1 (uncoupling protein 1) comes in several versions, and a number of studies have shown that people with a G version of this gene are prone to

obesity and have less success in weight-loss programs than people with another version, the A variant.

vi. Overweight/obese people with a gene version called PLIN4(A) tend not to lose more weight on low-calorie weight-loss diets.

vii. The Ala54Thr polymorphism of the FABP2 gene is associated with obesity and insulin resistance (Albala *et al.*, 2004:340). Fatty acid-binding protein (FABP) 2 is an intracellular protein expressed only in the intestine.

viii. One inflammatory substance called TNF-alpha, which is produced primarily in fat tissue, has been specifically associated with type 2 diabetes and insulin resistance, as well as obesity. Studies suggest that giving mice TNF-alpha produces insulin resistance, while blocking THF-alpha can improve insulin sensitivity.

ix. Scientific research has led to a growing awareness that genetics contribute substantially to the tendency towards binge eating. For example, an international team of physicians and scientists from Switzerland, Germany and the United States studied different variants of a gene called melanocortin 4 receptor, believed to be involved in the control of eating behaviour. They examined 470 obese men and women and found that 24 obese subjects had a slightly altered version of this gene. All of the subjects who carried this variant, reported binge eating. Among obese subjects without the altered gene, only 14% reported binge eating.

x. The D2 dopamine receptor (*DRD2*) gene has most commonly been linked to alcoholism, although the gene has been associated with other addictive behaviours such as smoking, illicit drug use, gambling, and overeating (Heber & Carpenter, 2011:162).

xi. While the *DRD2* gene increases the likelihood of food addiction and obesity, the *LEP-R* gene influences appetite control and has been associated with elevated levels of body fat and body composition (Heber & Carpenter, 2011:162).

xii. Genes can affect each component of energy balance and can explain some of the differences between individuals in body mass and body composition. Although one can conclude that genes are permissive for weight gain, the gradual weight gain of the population does not seem to be primarily due to genetic factors (Mitchell *et al.*, 2011:725).

xiii. Three adipokines that mediate obesity-related inflammation is tumor necrosis factor-alpha, interleukin-6 (IL-6) and adiponectin (Stryjecki & Mutch, 2011:2).

xiv. TNF-alpha is a pro-inflammatory cytokine whose expression and circulating levels are increased with obesity and decreased with weight loss (Stryjecki & Mutch, 2011:2). TNF-a has numerous effects in adipose tissue, including the regulation of apoptosis, adipogenesis, lipid metabolism and insulin signaling. Recent evidence suggest that individual SNPs in the genes encoding TNF-alpha, TNF-alpha receptor 2 and TNF-alpha-converting enzyme can modify an individual's risk for obesity-related complications (Stryjecki & Mutch, 2011:2).

xv. IL-6 is an inflammatory cytokine produced and secreted from white adipose tissue. In obesity, circulating concentrations of IL-6 are elevated and weight loss leads to a decrease in its levels (Stryjecki & Mutch, 2011:5).

As discussed above, adiponectin is an adipokine expressed in mature adipocytes. Adiponectin is the most abundantly secreted protein from adipose tissue, is anti-inflammatory, and regulates lipid and glucose metabolism, stimulates fatty acid oxidation, suppresses gluconeogenesis, increases insulin sensitivity, protect against chronic inflammation and regulates food intake and body weight (Stryjecki & Mutch, 2011:8). In humans, adiponectin gene expression is lower in visceral fat compared with subcutaneous fat, regardless of body weight, suggesting that subcutaneous fat depot plays a predominant role in regulating circulating adiponectin levels (Stryjecki & Mutch, 2011:8).

If the theories linking obesity, diabetes and inflammation are supported by further research, it may become critically important to identify obese people with overly active inflammatory genes – for example those with certain genetic versions of TNF-alpha. These people would advised to adopt a weight-loss diet that is also anti-inflammatory, in order to help avert such serious complications of obesity as insulin resistance and diabetes. It may also be possible in future to create drugs that will modify the function of these genes. Furthermore, such findings may also lead to non-pharmaceutical strategies that will allow us to compensate for our genetic limitations by adopting appropriate dietary and lifestyle measures in order to prevent chronic diseases linked to overweight/obesity (Stryjecki & Mutch, 2011:8).

2.4.4.2 Environmental factors

Lifestyle and environmental factors (referring to factors that can be modified by lifestyle changes) are responsible for activating or deactivating genes that trigger overweight/obesity (Lysen & Israel, 2012:467). Environmental factors that play a role in the aetiology of overweight and obesity, and which may be addressed in weight loss interventions, as discussed in chapter one, include dietary factors; lack of physical activity; lifestyle factors including smoking, alcohol consumption, sleep, stress and circadian rhythms, vitamin D status; and psychosocial factors.

Taste, satiety, and portion sizes are other environmental factors contributing to weight gain. The endless variety of food that is readily available let people eat more than when a single food is available (Israel & Lysen, 2012:469). Big portion sizes (especially at restaurants and fast-food outlets lead to passive overeating (Israel & Lysen, 2012:469).

Chronic overeating leads to inflammation that also contributes to weight gain and insulin resistance (Israel & Lysen, 2012:469).

Obesogens are foreign chemical compounds disrupting normal lipid metabolism. Bisphenol A and phthalates are examples of obesogens that can contribute to overweight/obesity (Israel & Lysen, 2012:469).

The intestinal microbiota has recently been suggested to contribute to the development of overweight/obesity and the metabolic syndrome (Serra-Majem & Bautista-Castaño, 2013:42). A published review has shown that the fact that gut microbiota can be modulated through dietary components highlights the importance of studying how fatty acids, carbohydrates, micronutrients, prebiotics, and probiotics can influence gut microbiota composition and the management of overweight/besity (Serra-Majem & Bautista-Castaño, 2013:42).

Certain drugs may cause weight gain or changes in body composition; these include insulin, sulfonylurea, thiazolidinediones, atypical antipsychotics, antidepressants, steroids, certain anticonvulsants (phenytoin and valproate), pizotifen, and some

forms of hormonal contraception (Lokuruka, 2013:7094; Abdullah & Azman, 2011:58).

The realisation that the environment is facilitating overweight/obesity, has increased interest in modifying the environment to help address the overweight/obesity epidemic. Therefore, behaviour modification to change lifestyle and modify the environment or the way an individual reacts to the environment, can help individuals develop a set of skills to achieve a healthy body weight (ADA, 2009:330).

Although research in this area is only emerging, it represents an exciting new approach to preventing and managing overweight/obesity (Mitchell *et al.*, 2011:725). According to Kruger *et al.* (2005:491) possible interventions to prevent and treat overweight/obesity should focus primarily on environmental factors to promote and support behavioural change.

2.4.5 Management of overweight and obesity in adults

The cornerstone of management via lifestyle modification includes setting realistic goals, and implementing a hypocaloric diet, combined with increased physical activity and behavioural techniques (Foster-Schubert *et al.*, 2012:1628). The NIH Obesity Education Initiative Expert Panel suggests an energy deficit of 500 – 1000 kcal/day (2100 – 4200 kJ) using an individualised dietary strategy, along with 45 minutes of moderate-intensity physical activity 5 days/week (Foster-Schubert *et al.*, 2012:1628). The Institute of Medicine recommends at least 1h/day of moderate intense physical activity, coupled with an energy deficit. The US Department of Agriculture similarly suggest that individuals engage in close to 1h of moderate-to-vigorous intensity exercise on most days of the week, without exceeding energy intake requirements (Foster-Schubert *et al.*, 2012:1628). The US Centre for Disease Control instead suggests at least 30 minutes/day of moderate-intensity exercise most days of the week while maintaining sensible portion sizes (Foster-Schubert *et al.*, 2012:1628).

2.4.5.1 Goals for weight loss

One of the first and most important factors in successful weight loss, is to set a reasonable weight loss goal (Kruger *et al*, 2005:496). Once the goal has been fixed, progress should be monitored regularly (Lokuruka, 2013:7096). A loss of 10% initial

weight for at least one year is considered successful (Garaulet & de Herdia, 2010:12). Even just losing 5 to 10% of initial weight will already have health benefits (Foster-Schubert *et al*., 2012:1628). These benefits include improved blood lipids, blood pressure, and cholesterol levels (Israel & Lysen, 2012:473).

2.4.5.2 The role of dietary components in weight loss

Long term strategies to maintain weight loss over time may include consideration of energy restriction, dietary macronutrient composition, meal timing, meal frequency and guidance on food portions (Jakubowicz *et al*., 2012:324; Hankey, 2010:34; ADA, 2009: 333).

i. Energy restriction

A successful energy reducing diet is one that an individual can adhere to for several months to lose 5% to 10% of initial weight (Wadden *et al*., 2012:1161). If a person consumes a diet that provides 2100 – 4200 kJ (500 – 1000 kcal) less than is needed for the activities of daily life, excess reserves of energy in adipose tissue will be drawn upon and weight loss will theoretically occur at a rate of 0,5 – 1kg per week (Lokuruka, 2013:7096; Te Morenga *et al*., 2011:41; ADA, 2009: 333). Total energy intakes of equal to, or more than 5500 kJ per day, is recommended to ensure adequate nutrient intakes (Te Morenga *et al*., 2011:41). According to Ramage *et al*. (2014:14) a weight loss diet should provide at least 5040 kJ per day. This agrees with the US National Institutes of Health recommendation that safe weight-loss diets (combined with physical activity) should ideally not provide less than 5020 kJ for women and 6300 kJ for men (Kruger *et al*., 2005:496). If dietary intake is below 4200 kJ (1000 kcal) per day, excessive losses of potassium and nitrogen may occur (Lokuruka, 2013:7097).

The National Institute for Health and Clinical Excellence clinical guideline also supports the use of an approach with the statement ‘Diets have a 600kcal/day deficit (that is they contain 600kcal less than the person needs to stay the same weight) or that reduced calories by lowering the fat content (low-fat diets), in combination with expert support and intensive follow-up, are recommended for sustainable weight loss’ (Hankey, 2010:34).

ii. Macronutrient composition

Macronutrient composition of the diet has been shown to influence hunger, satiety and cravings. Several studies have shown that dietary protein is the most satisfying of the macronutrients in conditions of both energy restriction and energy balance. It has also been shown that the addition of carbohydrates to protein, leads to additional reduction of hunger and increased satiety (Jakubowicz *et al.*, 2012:324). However, some studies found that energy restriction rather than macronutrient composition is the key determinant of weight loss (Ramage *et al.*, 2014:14; Wadden *et al.*, 2012:1161; Hankey, 2010:37). Weight loss is not significantly different between carbohydrate-rich and carbohydrate-poor diets (as will be discussed later), suggesting that it is the reduction in total energy intake what determines weight loss, regardless of the proportion of nutrients (Garaulet & de Heredia, 2010: 13).

The Institute of Medicine (IOM) recommends 130g/day of carbohydrate, based on the amount of sugar and starch required to provide the brain with an adequate supply of glucose. The IOM also recommend that carbohydrate constitute 45 – 65% of total daily energy (Slavin, 2012:S113). Some studies suggest that carbohydrates should make up only 40 – 45% of total energy intake (Catsicas, 2014:7). Currently, the consensus among recommendation authorities is that more research is needed before national or international recommendations can be changed. Until then carbohydrates is recommended to constitute almost half of all energy consumed, preferably in the form of fibre-rich foods (Mozaffarian *et al.*, 2011:2396).

Diets that do not ensure recommended macronutrient distribution, i.e. 10 – 15% protein, 30 – 35 % fat, and 50 – 60% carbohydrates, are not deemed suitable for behavioural therapy (Garaulet & de Heredia, 2010:13). Nutritionally-unbalanced approaches are most likely to be unsustainable in achieving long-term weight control (Hankey, 2010:34).

Garaulet & de Heredia (2010:13) summarises current evidence as that weight loss diets should be hypocaloric, with energy contents *of at least* 1000 kcal (4200kJ), with ≥0,8g protein/kg body weight/day and ≥100g carbohydrates/day to avoid ketogenesis; and should encouraged healthy habits, such as adequate breakfast, not missing meals (eating 3 – 5/day), eating slowly, and moderate portion sizes.

iii. Meal frequency and timing

Consuming smaller, more frequent meals, is often advocated as a means of controlling body weight. With regards to weight control, the influence of meal frequency is yet to be firmly established (Schwarz *et al.*, 2011:9). To date, some evidence suggests that less frequent meal consumption, with a large bolus of energy at each meal, can lead to increases in adipose tissue, while some studies have positively linked between-meal snacking with increased BMI (Schwarz *et al.*, 2011:9). Hartline-Grafton *et al.* (2010:736), found that neither number of meals, snacks, or overall frequency of eating was associated with BMI. Recently, Ohkawara *et al.*, (2013:336) reported that increasing meal frequency from three to six times per day, had no significant effect on 24-hour fat oxidation, but may increase hunger and the desire to eat.

The frequency as such of food consumption is not necessarily associated with overweight/obesity; it is probably mostly rather the total energy intake that the daily food eating consumption surmounts to, that influences weight gain, as was found by Mills *et al.* (2011:552) among middle aged women. Studies show that small frequent meals may benefit the secretion of ghrelin, insulin and cortisol in ways that may benefit weight control (Schwarz *et al.*, 2011:11). Postprandial insulin levels have been found to be more controlled with more frequent meals, while skipping meals (primarily skipping breakfast) has been associated with higher postpranial levels of insulin (Schwarz *et al.*, 2011:11).

On the other hand, eating breakfast have been shown to protect against obesity, as the frequency and quality of breakfast have been related to appetite and blood sugar control. Breakfast is defined as the first meal of the day, eaten before or at the start of daily activities (e.g. errands, travel, work), within two hours of waking, typically no later than 10:00 in the morning, and of an energy level between 20 and 35% of total daily energy needs (Pereira *et al.*, 2011:163). A good quality breakfast refers to fibre- and nutrient-rich whole grains, fruit, and low-fat dairy (Pereira *et al.*, 2011:163). High-protein intake (25% of the meal kilojoules from protein) at breakfast may support sustained satiety. Consuming egg with breakfast, for example, has been found is associated with significantly less "hunger" and a feeling of satisfaction (Schwarz *et al.*, 2011:8). Furthermore, eating in response to hunger and satiety

signals, is strongly associated with lower BMI in middle aged women (Madden *et al*., 2012:2272).

Some scholars believe that it is best to eat carbohydrates mostly at dinner, as this appears to have additional benefits when compared to a conventional weight loss diet in individuals suffering from obesity. The mechanism seems to involve changing the pattern of leptin secretion (Sofer *et al*., 2011:2007).

iv. Portion control

The American Dietetic Association (ADA) (2009:334) recommends that portion control should form an integral part of a comprehensive weight management program. Research have shown, that by increasing portion sizes during an eating occasion, energy intake is increased, but this is not compensated for by a decrease in intake later in the day (ADA, 2009:334). According to the ADA (2009:334), portion control strategies may include providing information about the energy content of different types of foods which are regularly consumed; using premeasured foods; reducing the energy density of dishes; and/or replacing energy-dense foods with less energy-dense foods. These strategies may affect the hedonic system that govern eating behaviour (eg, taking conscious decisions to forgo a more palatable food in favour of a less energy-dense food); or the homeostatic system (eg, reduced portions may be more or less satiating depending on the strategy used) (ADA, 2009:334) Effective weight loss was demonstrated in randomised controlled trials in which participants applied the above mentioned specific portion control strategies, versus compiling their own diet from an exchange system (ADA, 2009:334).

iv. *The* role of specific foods and food components

In the following section the role of specific foods and food components in weight management strategies will be discussed.

a. Grains and starches

Weight gain has been positively linked to increased consumption of refined grains. The weight gain associated with refined grains, was found to be similar to that for sweets and desserts (Mozaffarian *et al.*, 2011:2396).

Whole grain consumption has been positively linked with improved blood lipids and reduced risk of coronary artery disease, cardiovascular disease, type 2 diabetes, obesity, and some cancers (Smith *et al.*, 2014:136). Whole grains refer to the intact grain or the de-hulled, ground, milled, cracked, or flaked grain where the endosperm, germ and bran are present in the same proportions as found in the whole kernel. Whole grains include rolled oats, barley, brown wild rice, crushed wheat, quinoa, bulgur wheat, corn, millet, high-fibre wheat cereals, heavy whole grain breads and pure rye breads. Besides fibre, whole grains contain B vitamins, vitamin E, iron, phosphorus, as well as phytochemicals like phytoestrogens and phenolic compounds, which together are protective against disease (Catsicas, 2014:7; Smith *et al.*, 2014:136).

Although suggestions have been made that wheat consumption has adverse effects on health by mechanisms related to addiction and overeating, Brouns *et al.* (2013:209) showed that consumption of whole wheat was not linked to the increased prevalence of obesity in the general public.

To increase overall fibre intake, it is recommended to include fibre-rich carbohydrate foods, such as whole grains, vegetables, fruits, and cooked legumes (dry beans and peas) as staples in the diet (Øverby *et al.*, 2013:20712).

b. *Dietary* fibre

Dietary fibre is defined as the edible parts of plant foods that are resistant to digestion and absorption in the human small intestine, and which is completely or partially fermented in the large intestine (Du *et al.* 2010:329). Higher intakes of dietary fibre (especially cereal fibre as described above) may protect against weight gain and increased WC (Du *et al.* 2010:329).

Two types of fibre are distinguished; namely soluble and insoluble. Soluble fibre comes from legumes, some fruit and oats, and has beneficial metabolic effects. Soluble fibre influences digestion and plays an important role in the absorption of glucose and lipids (Vorster, 2013:S31). Insoluble fibre is mainly bran from cereals. It affects fermentation, plays a role in stool weight and form healthy bowel habits (Vorster, 2013:S31).

The recommendations of fibre intake vary very little between dietary guidelines. The Nordic Nutrition Recommendations (NNR) for dietary fibre is 25 – 35g/day (Øverby *et al.*, 2013:20709).

The ADA (2009:330) recommends 20 – 35g of fibre per day for healthy adults. According to the USDA Food Guide Pyramid six to eleven starch portions is adequate (Bonnie, 2004:304). And according to dietary guidelines for Canadians at least half (three to five) of these should be whole grain (Escott-Stump & Earl, 2008:342).

The American Heart Association (AHA) and European Society for Atherosclerosis (ESA) recommend daily intake of 5 - 15g of soluble fibre as part of the nutrition intervention for treating dyslipidaemia. This may be achieved by a minimum of five portions of fresh fruit and vegetables and three portions of whole grains daily. It has been suggested that future research should investigate the effects of large doses of insoluble fibre (33 - 41g), in addition to a higher protein diet, to determine if this combination could further decrease appetite and energy intake (Schwarz *et al.*, 2011:9).

c. Vegetables and fruit

Weight gain has been associated with lower vegetable (Vergnaud *et al.*, 2010:399) and fruit intakes (Mozaffarian *et al.*, 2011:2392; Williams, 2012:1929). Vegetables and fruit have high water and fibre content, with low energy density, while being rich in vitamins, minerals, phytochemicals and antioxidants. Vegetables and fruit may protect against adiposity by by increasing satiating and displacing energy-dense foods in the diet so that fewer kilojoules is consumed overall (Ledoux *et al.*, 2010:e143). Dark-green vegetables are particularly rich sources of antioxidants, which are substances that may protect against oxidative damaging effects of free

radicals, which damage cells and play a role in the aetiology of heart disease, cancer and other NCDs. Orange coloured vegetables (e.g. pumpkin and carrots) contain high amounts of ß-carotene, which is a powerful antioxidant, but is also converted to vitamin A in the body. An adequate amount of vitamin A is needed to maintain eye health and boost the body's immune system to fight infectious diseases (Labadarios *et al.*, 2011; Labadarios, 2007).

Eating solid vegetables and fruit, instead of consuming juices, are recommended for weight management (Houchins *et al.*, 2012:1849). Whole fruit (including the skin and pulp) provides more nutrition than fruit juice. The edible skins of many fruits are sites of important biological activity, but are sometimes removed when fruits are juiced. The skin of the fruit interacts with sunlight, and forms a variety of colored pigments such as carotenoids and flavonoids. The skin is also an important source of dietary fibre (Houchins *et al.*, 2012:1849).

d. Meat

Higher meat intake is significantly and consistently associated with greater BMI and WC (Williams, 2012:1929; Vergnaud *et al.*, 2010:398). Epidemiological studies have suggested that high meat and animal protein intakes are also associated with increased risk of insulin resistance and the metabolic syndrome (Te Morenga *et al.*, 2011:46).

Vergnaud *et al.* (2010:398) estimated that an increased meat intake of 250g/day (e.g. one steak), would lead to a 2kg higher weight gain after five years. Positive associations with weight gain were observed for red meat, poultry, and processed meat. Their results suggest that a decrease in meat consumption may improve weight management.

e. Eggs

In a particular study it was found that an egg with breakfast was associated with significantly less "hunger", and greater feelings of satisfaction three hours after consumption, than a breakfast consisting of a bagel instead (Schwarz *et al.*, 2011:8).

This is due to the high protein content of an egg that delays gastric emptying and increase feeling of fullness.

f. Legumes

Some research has shown that consumption of legumes, which constitute a wide selection of beans and peas, is inversely associated with coronary heart disease and CVD. Soy protein is known to improve blood lipids by a small, but significant degree (Smith *et al.*, 2014:136). Based on the high fibre content and the cardio-protective effects, including legumes in a diet designed for weight loss may therefore be beneficial.

Peanuts, consumed as such or in the form of peanut butter, is another popularly consumed form of legume. Peanuts are however higher in fat content than beans or peas (Alves *et al.*, 2014:1422).

g. Dairy

Weight gain may be inversely associated with dairy consumption (Vergnaud *et al.*, 2010:399). Low intake of dairy products have been postulated to contribute directly to the global obesity pandemic (Lanou & Barnard. 2008:272). Numerous studies have shown high dairy intake is associated with decreased risk of all-cause mortality, ischemic heart disease, stroke, and diabetes, and an inverse relationship between high dairy or calcium intake and bodyweight, body fat, and BMI have been documented (Smith *et al.*, 2014:136).

Dietary approaches for weight loss which include higher dairy intakes, promotes favourable body composition changes in women, characterised by greater total and visceral fat loss and lean mass gain (Josse *et al.*, 2011:1626). Low fat dairy products may also contribute to maintain a healthy body weight and appetite control (Gilbert *et al.*, 2011:133).

The combination of nutrients in dairy products, particularly protein and calcium, may be responsible for weight loss and weight maintenance through its impact on energy metabolism. A high-calcium diet also suppresses the influx of calcium into fat cells,

and this stimulates fat breakdown and inhibits fat storage, thus protecting against overweight/obesity (Huth *et al*., 2006:1207).

Calcium-rich food sources are recommended rather than supplementing with calcium (Smith *et al*., 2014:136) because the combination of nutrients in dairy products are perfect for optimum calcium absorption and utilization (Huth *et al*., 2006:1207).

h. Dietary fats

The position of the Academy of Nutrition and Dietetics is that dietary fat should provide 20 – 35% of total energy, with an increased consumption of n-3 PUFAs and limited intake of saturated and *trans* fats (Position of the Academy of Nutrition and Dietetics, 2014:136).
Excessive total dietary fat consumption increases the risk of overweight/obesity, coronary heart disease and certain types of cancers (Smuts & Wolmarans, 2013:S92). A meta-analysis of 16 trails, however, concluded that moderate-fat diets (e.g. Mediterranean diet) resulted in more weight loss than low-fat diets, especially in heavier subjects (Smuts & Wolmarans, 2013:S93).

Total fat intake has been the primary focus of dietary recommendations, and the importance of individual fatty acids has been overlooked. Instead of focusing on total fat content of the diet (or even saturated and unsaturated fat, the focus should be on individual fatty acids and location of double bonds in their composition. Whether the double bond is located on carbon number three or six (as in n-3 and n-6 PUFA) makes a big difference in biological function (eg, vasoconstriction vs vasodilation) (Khaw *et al*., 2012:e1001255).

Linoleic acid from the omega-6 PUFA family and α-linolenic acid from the omega-3 PUFA family, are essential nutrients which have to be consumed in the diet to avoid deficiency. These fatty acids are involved in a wide variety of important physiological processes like brain development, while others affect the development of NCDs later in life (Smuts & Wolmarans, 2013:S87). Furthermore, a diet enriched in omega-6 PUFA family exerts pro-inflammatory effects, while a diet enriched in omega-3 PUFA is less inflammatory (Smuts & Wolmarans, 2013:S87). This may be relevant to weight management, as obesity is an inflammatory process as discussed before. Indeed, supplementing with 4g of fish oil daily (1600mg/day eicosapentaenoic acid

and 800mg/day docosahexaenoic acid) has been linked to increased fat free mass and decreased fat mass after six weeks (Schwarz *et al.*, 2011:12).

According to dietary guidelines for Canadians 2 x 90g portions of fish should be consumed weekly (Escott-Stump & Earl, 2008:342).

i. Added sugar

The suggestion that sugar might have adverse health effects has been recurring for decades, with claims that high intake may be associated with an increased risk of conditions as diverse as dental caries, overweight/obesity, cardiovascular disease, diabetes, gout, fatty liver disease, some cancers, and hyperactivity. However, inadequate study design, differences in assessing dietary intake, inconsistent findings, and varying definitions of "sugars' have precluded definitive conclusions regarding these associations (Te Morenga *et al.*, 2013:7492).
The intake of sugar sweetened beverages, which is highly energy-dense and very easy to consume in excess, have however been convincingly linked to body weight in many studies (Malik *et al.*, 2010:2478).

The prevalence of overweight/obesity has increased dramatically since the 1970s in parallel with significant increase in the consumption of sweetened beverages (Austin *et al.*, 2011:841). Soft drinks, sugar and sweets are more likely to have a negative impact on diet quality, whereas dairy foods, milk drinks and pre-sweetened fortified breakfast cereals may have a positive impact (MacIntyre *et al.*, 2012:129).

But excessive intakes of any food or beverage can cause weight gain. When total energy intake is controlled, sugar should not cause weight gain (Van den Berg, 2011:258).

When sugar is consumed in moderate amounts, it does not have a negative effect on dental health, mental health and behaviour, weight management, chronic diseases of lifestyle, or the intake of micronutrients (Van den Berg, 2011:258).

Excessive intake of sugar or sugar-sweetened beverages is not recommended as it may lead to weight gain. It is recommended that sugar-sweetened beverages should not exceed 400-600kJ per day (Johnson *et al.*, 2009:1011). The

recommendation that added sugar should constitute less than 10% of total energy has been accepted for many years (Te Morenga *et al.*, 2013:7493). The WHO has, however, recently decreased the recommendation for added sugar intake to 5% of total energy intake (Thow & Hawkes. 2014:2151). In South Africa recommendations are that added sugars should not exceed 55g per day (six to ten per cent of total energy intake) (MacIntyre. 2012:124).

j. Eating out

Fast foods are known to be generally high in energy and total fat, and some are also high in saturated fatty acids (Smuts & Wolmarans, 2013:S90). The portions and energy-content of a single meal from most restaurants and fast food-outlets, often exceed a person's energy needs for the entire day (Lysen & Israel, 2012:469). Preparing food and eating at home is associated with better weight control, as studies indicate that a decrease in the number of meals prepared "from scratch", increases the probability of being overweight (Kolodinsky & Goldstein, 2011:2327).

2.4.5.3 Popular dietary approaches for weight-loss

Various dietary strategies can effectively reduce weight (Makris & Foster, 2011:820; (Naude *et al.*, 2014: online), and a wide variety of popular approaches have been studied. These include low-fat diets, very low fat diets, very-low-energy diets, moderate-fat diets, high-protein diets, low-carbohydrate diets, low-glycemic index diets, and the Paleo diet.

i. Low-fat diets

The South African Food based dietary guidelines of low fat diets, are based on evidence that eating a low fat diet (20 – 35% of total energy) supports weight manage, promotes health, and reduces the risk of chronic disease. These guidelines include recommendations for "foods to reduce" (i.e. saturated and trans fat, cholesterol, sodium, added sugar, refined grains, alcohol) and "foods to increase" (i.e., fruits, vegetables, whole grains, low-fat dairy and protein foods, oils) in order to maximise the nutrient content and health promoting potential of the diet (Makris & Foster, 2011:813).

Low-fat diets are the best studied of all dietary approaches to weight loss (Makris & Foster, 2011:813). Studies have demonstrated that greater weight loss is achieved in groups consuming low-fat diets compared to controls receiving standard lifestyle recommendations, while this approach also exerts positive effects on comorbid conditions (Makris & Foster, 2011:814). Low-fat diets (15 – 20% total energy as fat) have proved to be effective in reducing weight loss in the short term (6 – 12 months), but less significant effects have been observed in the long term (Garaulet & de Heredia, 2010:13). However, a low-fat diet is deemed an effective weight control strategy in the short term, as well as the long-term, as long as it is followed (Makris & Foster, 2011:814).

ii. Very-low-fat diets

Some investigators have suggested that fat intake of ≤20% of total energy is necessary for optimal health. Diets that provide 10 – 20% fat are defined as very low in fat and are primarily plant-based (including fruit, vegetables, whole grains, beans, and soy), with limited amounts of reduced fat dairy, eggs, lean meats, and fish. Unlike low-fat plans, which incorporate all foods, the very low-fat diets strongly discourage consumption of foods containing high amounts of refined carbohydrate (Makris & Foster, 2011:815). Very low-fat diets may, however, be more difficult to sustain over time (Makris & Foster, 2011:815).

iii. Very-low-energy diets

Very-low-calorie diets (VLCD) are defined as providing around 3347kJ per day, and has been successfully used to achieve intentional weight loss over a short period of time (Hankey, 2010:35). In most cases such treatments are available over the counter in the form of drinks and some pre-prepared snacks (Hankey, 2010:35). This type of diet therefore does not permit "patients" to acquire new eating habits gradually, which is essential for long-term success (Garaulet & de Heredia, 2010: 13; Hankey, 2010:35). Although VLCD have proved to be of little use in long term weight loss, they may have a role in weight management for particular patients, with the most obvious group being those who are obese and awaiting surgery (Hankey, 2010:35).

iv. Moderate-fat diets

Some studies have shown that weight loss was better maintained over time in individuals who followed a moderate-fat diet and suggested that it may be easier to adhere to moderate-fat diets than low-fat diets over the long term. Recent studies that have compared moderate-fat (i.e., 35 – 45% fat) and low-fat (i.e., 25 – 30%) diets, have reported similar to slightly better weight losses with moderate-fat diets (Smuts & Wolmarans, 2013:S93). These diets were similar to Mediterranean diets in that they contain a high proportion of monounsaturated fatty acids (MUFAs), primarily from MUFA rich oils, and emphasized high intake of plant foods (i.e., fruits, vegetables, whole grains, legumes, and nuts) and fibre, and limited amounts of saturated fat from animal foods (Makris & Foster, 2011:815).

Given that low-fat diets can contain up to 35% fat, moderate fat diets are generally those that contain between 35 – 45% fat. Therefore, though many people equate moderate-fat diets with a Mediterranean diet, the fat content of the Mediterranean diet can vary considerably. Some have reported fat contents as high as 47% of total energy, while others reported fat content of as low as 25% of total energy; therefore, although some Mediterranean diets can be considered moderate in fat, it should not be assumed that all are (Makris & Foster, 2011:815).

The Mediterranean diet covers most nutritional recommendations, like low content of refined carbohydrates, high fibre content, moderate fat content, mostly unsaturated, and moderate-to-high content of vegetable proteins (Garaulet & de Herdia, 2010:10).

<table>
<tr><td>Increased intake of grains and pulses</td><td rowspan="4"></td><td rowspan="2">Increase fibre, vitamins and minerals</td></tr>
<tr><td>Increased proportion of vegetables and fruits</td></tr>
<tr><td>Decreased intake of dairy products (mainly as cheese and yoghurt)</td><td rowspan="2">Decrease content of saturated fat</td></tr>
<tr><td>Decreased intake of meat and fish. Pulses as main source of protein</td></tr>
</table>

Olive oil as main fat source		Protect against CVD
Moderate intake of wine during meals		

Figure ___: Main features of the Mediterranean diet (Garaulet & de Herdia, 2010:15)

Moderate-fat diets have been associated with favourable effects on diabetes risk factor (i.e., reduction in fasting insulin and improvements in homeostasis model assessment of insulin resistance) and CVD risk factors (i.e., reduced ratio of low-density lipoprotein [LDL] to HDL) (Makris & Foster, 2011:815). The Mediterranean diet has been shown to be superior to low-fat diets in increasing HDL and reducing atherogenic index (i.e., ratio of total to HDL cholesterol) and C-reactive protein in individuals with hyperlipidaemia or coronary heart disease; while being comparable in improving blood pressure, HDL, HbA1C, and fasting glucose and insulin in individuals with type-2 diabetes (Makris & Foster, 2011:815).

Ideally the application for the Mediterranean diet for weight loss purposes must be accompanied by reduced energy intake (reductions of 500 – 1000 kcal/day); fat must not exceed 30% energy, and oleic acid must continue at least 55% total fat at the expense of saturated fats – this can be attained by using olive oil as culinary fat (Garaulet & de Heredia, 2010:14). The Mediterranean diet has been hailed as the healthiest food model (Serra-Majem & Bautista-Castaño, 2013:38). Regarding the treatment of obesity, the main advantages of the Mediterranean diet are attributed to the fact the following caharcteristics (Garaulet & de Heredia, 2010:14):

i. It is highly satiating, due to high fibre intake;
ii. It is composed of high volume foods with low-energy density;
iii. Given its high carbohydrate content, it does not trigger specific hunger and therefore binge eating;
iv. For the same reason, it is not ketogenic;
v. Even though it can by hypocaloric, it keeps adequate nutrient proportions;
vi. It is healthy;

vii. It can be followed over the long term (which is important for maintenance purposes); and

viii. It is tastier than other low-fat regimens. Olive oil enhances the flavour of certain foods and contributes to increase vegetable intake.

Behavioural therapy based on the Mediterranean diet is also useful to treat obesity, because the diet provides the individual with an eating plan established on widely recognised nutritional benefits, which is adaptable to their daily and social life, and which is easy to follow in the long term. This approach contributes to stable weight loss (Garaulet & de Herdia, 2010:9).

v. High-protein diets

There is no standard definition of a "high-protein diet", however, intakes greater than 25% total energy, or 1.6 g/kg per day of body weight, can be considered high. According to Te Morenga *et al*. (2011:41) the diet prescription for a high protein diet is 30% of total energy as protein, and 40% of total energy as carbohydrates.

Some studies report greater weight loss and improvements in body composition (i.e. decreases in WC, WHR, and intra-abdominal adipose tissue; and better preservation of lean body mass) in individuals prescribed high-protein diets, than low-fat diets (Schwarz *et al*., 2011:9). These findings have also specifically been reported among women (Josse *et al*., 2011:1626), and individuals with elevated risk of CVD and metabolic syndrome (Makris & Foster, 2011:816). Dietary protein improves postprandial satiety and higher intakes may be associated with improved weight maintenance.

The appeal of the high-protein diets is that protein is thought to provide more satiation per kilojoule than fat or carbohydrates (Katan, 2009:923). There is, however, ongoing controversy about the effects of dietary protein on glucose metabolism. Several studies showed that dietary protein, apart from saturated fatty acids, which may accompany animal protein in meat and cheese itself, seem to cause insulin resistance in both cross-sectional and experimental studies (Gögebakan *et al*., 2011:2830). Other studies showed that an increased protein content of up to 30% of energy intake, has beneficial effects on postprandial and

fasting plasma glucose concentrations, particularly in insulin-resistant subjects. Favourable effects of high-protein intake on blood pressure and blood lipids were described in subjects with elevated cardiovascular risk factors, but effects on inflammatory markers were not investigated in large human studies (Gögebakan *et al.*, 2011:2830). Obese women with elevated TAG concentrations, who consumed a high-protein for 12 weeks lost 50% more body fat, than those who consumed an isocaloric low-fat diet (Makris & Foster, 2011:817). Some studies in high risk overweight and obese women, a realistic high protein weight-reducing diet has been associated with greater fat loss and lower blood pressure when compared with a high carbohydrate, high fibre diet (Te Morenga *et al.*, 2011:40). These findings suggest that high-protein diets may be of some benefit to individuals with, or at high risk for diabetes, dyslipidaemia, CVD, and metabolic syndrome (Makris & Foster, 2011:817).

Regarding protein shakes, it would appear to be most beneficial if the additional protein is ingested from solid food sources as food form also appears to play a role in feelings of satiety (Schwarz *et al.*, 2011:9). Unfortunately high-protein diets have a poor long-term adherence (Makris & Foster, 2011:816).

vi. Low-carbohydrate diets

The FDA has not established a clear definition for "low" carbohydrate. Low-carbohydrate diets often consist of limited amounts of carbohydrate (20 – 25g/day or about 10% of energy as carbohydrate), and relatively high amounts of fat (approximately 60% of energy as fat), which differentiates low-carbohydrate diets from high-protein diets. Less strict low-carbohydrate dietary approaches may encourage consumption of controlled amounts of nutrient dense carbohydrate containing foods (e.g. low GI vegetables, whole grain vegetables) and eliminate intake of refined carbohydrate. Although consumption of foods that do not contain carbohydrate (e.g. meats, poultry, fish, butter, oil) is not restricted, quality rather than quantity is emphasised (Makris & Foster, 2011:818).

As carbohydrates are restricted, glycogen stores are depleted and diuresis cause initial dramatic weight loss (Johnstone *et al.*, 2008:44).

The principle behind these diets is that high intakes of carbohydrates render serum insulin levels higher, promoting fat storage. These types of diets do, however, can be useful in the short term. Low carbohydrate diets inevitably have high concentrations of protein and fat, and rapidly deplete the glycogen stored in the liver and activate the ketosis system as a result of fat oxidation. Therefore, short term weight loss is largely a consequence of water loss due to glycogen depletion – especially during the initial phase of the diet, when hydrated glycogen is catabolized to maintain plasma glucose levels – and excretion of ketone bodies (Garaulet & de Heredia, 2010:13). Long-term effects of low-carbohydrate diets remain unknown (Naude *et al*., 2014: online).

However, differences in weight loss did not persist at one year. A meta-analysis published in 2006 also found no significant differences in weight loss between diets at one year suggesting that low-carbohydrate diets are as effective as low-fat diets for weight loss (Makris & Foster, 2011:818). This is confirmed by Naude *et al*. (2014: online) that low-carbohydrate and balanced diets probably have similar effects on the known risk factors for heart disease in overweight and obese people with or without diabetes.

There have been concerns about the effects of low-carbohydrate diets on CVD risk and bone health. With regard to CVD risk, most studies found that low-carbohydrate diets decreased TAG and VLDL and increased HDL more than low-fat diets in the short term. However, these changes were not sustained in the long-term, with the exception of HDL (Hankey, 2010:35).

There are many gaps in our understanding of how these diets work and whether they are healthy in the long term. Because of the lack of consensus among health professionals about low-carbohydrate diets, using these diets to manage weight is controversial. (Lenard &Berthoud, 2008:S13). Given our current understanding, it does not appear that low-carbohydrate diets trigger any adverse effects on lipid variables. In addition, no differences in body composition or bone mineral density were observed between a low-fat and low-carbohydrate diet at any point is a two-year study (Makris & Foster, 2011:819). Low-carbohydrate diets are however associated with a significantly higher risk of all-cause mortality (Noto *et al*., 2013:e55030) and more studies are needed to assess their long-term effects.

vii. Low-glycemic index (GI) diet

Carbohydrates vary in the degree to which they raise blood glucose and insulin levels. The term “glycemic index” (GI) refers to a property of carbohydrate-containing food that affects the change in blood glucose following the food consumption. Carbohydrate containing foods are ranked in relation to glucose or white bread, which both have a GI of 100. Thus, foods with a GI between 0 – 55 are considered low GI foods, those with a GI of 70 or greater are considered high GI foods, and those that fall between these two ranges are categorised as intermediate GI foods. A variety of factors such as carbohydrate type, amount and type of fibre, degree of processing, cooking, storage, acidity, food structure, and micronutrient content can all affect GI. Glycemic load (GL) is a similar concept but takes into account both the type of carbohydrate and the amount of carbohydrate consumed (Makris & Foster, 2011:819).

A low GI or GL diet is a unique blend of low-fat and low-carbohydrate concepts. Recommendations for this dietary approach are based not only on the GI values of food, but also on the overall nutritional content of the diet. The overall goal of GI eating is to obtain adequate energy and nutrients without causing large spikes in insulin and blood glucose levels (Makris & Foster, 2011:819). Only a limited number of studies have, however, evaluated the effects of GI on weight maintenance, and findings are mixed (Makris & Foster, 2011:820). In a large and multinational cohort, it was confirmed that a low-fat, low-GI food pattern is overall beneficial. A lower GI diet was correlated with favorable effects on blood lipids, particularly low-density lipoprotein cholesterol (LDL) and triglycerides and a lower level of high-sensitivity C-reactive protein as a marker of low-grade inflammation (Gögebakan *et al.*, 2011:2830). A low GI diet also increases satiety and keep blood sugar levels stable (Makris & Foster, 2011:819). Although low GI diets may play an important role in the prevention and treatment of metabolic and cardiovascular disease, there is no advantages in terms of weight loss when GI is altered and energy and macronutrient composition are held constant (Makris & Foster, 2011:819).

viii. Paleo diet

The Paleolithic (Paleo) diet is modeled after the perceived food consumption of early human ancestors of the Paleolithic Era, consisting of mainly meat, fish, fruit, vegetables, eggs and nuts (Smith *et al.*, 2014:128).

The Paleo diet reputedly encourages the consumption of foods that are satiating, rich in micronutrients, and often, good sources of fibre, essential fatty acids, and essential amino acids, while restricting the consumption of a number of foods that are energy dense and low in micronutrient content. Replacing highly processed, energy-dense foods with the "Paleo-approved" foods, would be beneficial and achievable for many individuals, however, the diet unnecessarily restricts the consumption of foods that can contribute to a healthy diet, including dairy, whole grains, and legumes (Smith *et al.*, 2014:136).

The Paleo diet allows dieters to consume plenty of high-protein foods and fruit, which have been shown to be highly satiating food sources. Direct comparison of the Mediterranean and Paleo diets has shown that subjects report higher levels of satiety per calorie from the Paleo diet (Smith *et al.*, 2014:136). Furthermore, studies have shown that the low carbohydrate to protein ratio commonly associated with the Paleo diet, improves glycemic control and body composition (Smith *et al.*, 2014:136).

In the other hand, some study showed that this diet is associated with deleterious changes to blood lipids in healthy subjects, despite current improvements in body composition and cardiorespiratory fitness (Smith *et al.*, 2014:128). A truly *ad libitum* application of the Paleo diet, without restrictions on intakes of fatty meat, eggs, nuts, and oils, could potentially be conducive to high intakes of total fat, saturated fat, and cholesterol (Smith *et al.*, 2014:130), due to the fact that food is simply more readily available nowadays than it was in the Paleolithic Era. The diet can cause a decrease in body weight and body fat percentage, but with a potential negative impact on non-HDL, LDL, TC, and TC/HDL; and no significant change in HDL (Smith *et al.*, 2014:134).

2.4.5.4 A balanced dietary approach

In conclusion, a diet that promotes sustained weight loss, yet protects against NCDs, for adults seems to require energy restriction to promote 0.5 – 1kg weight loss per week, and include a balanced __________

Restrictions should, however, not be too rigid. No diet is effective, unless it is followed over the long term and establishes lifelong habits (Garaulet & de Heredia, 2010:14). Flexibility in the diet is associated with less cravings and binge-eating, and greater success in maintaining weight loss. A controlled diet should include the occasional treat, including alcohol and sweets, which should be enjoyed without feeling guilty (Garaulet & de Heredia, 2010:14).

Tools for formulating a balanced diet, include the United States Department of Agriculture / United States Department of Health and Human Services (USDA/DHHS) Dietary Guidelines, and the South African Food Based Dietary Guidelines (SAFBDG).

i. Dietary guidelines

The USDA Dietary Guidelines is a comprehensive document which summarised dietary recommendations for Americans (Goa *et al.*,2006:1341). In summary this guideline recommends six to eleven starch portions/day (Bonnie, 2004:304), and also stratifies this across various levels of energy intakes (Goa *et al.*,2006:1341). The Dietary Guidelines for Canadians suggest that at least half of these should be whole grain (Escott-Stump & Earl, 2008:342). Three to five vegetable portions are recommended per day, with fewer than three portions being insufficient. The Dietary Guidelines for Canadians recommend that these should include at least one green leafy vegetable and one orange vegetable per day (Escott-Stump & Earl, 2008:342). Two to four fruit portions are recommended, with fewer than two being insufficient (Bonnie, 2004:304). Meat and meat substitutes can be eaten daily. Two to three portions of meat or meat substitutes are considered to be adequate (Goa *et al.*,2006:1341). One meat portion is 30g meat or chicken or fish. One portion meat substitute is equal to 30g cheese, 1 egg, ¼ cup cooked legumes, 1 tablespoon peanut butter, or 15g seeds/nuts. According to dietary guidelines for Canadians two 90g portions of fish should be consumed weekly (Escott-Stump & Earl, 2008:342). Two to three dairy portions per day: fewer than two portions is insufficient and more than three is considered high (Bonnie, 2004:304). Six to seven portions is considered adequate amounts of dietary fat, with five or fewer portions being insufficient, and eight or more fat portions, excessive (Bonnie, 2004:304).

The South African food-based dietary guidelines help people make sound nutritional choices. They are (Vorster *et al.*, 2013:S7):

- Enjoy a variety of foods.
- Be active!
- Make starchy foods part of most meals.
- Eat plenty of vegetables and fruit every day.
- Eat dry beans, split peas, lentils and soya regularly.
- Have milk, *maas* or yoghurt every day.
- Fish, chicken, lean meat or eggs can be eaten daily.
- Drink lots of clean, safe water.
- Use fats sparingly. Choose vegetable oils rather than hard fats.
- Use sugar and foods and drinks high in sugar sparingly.
- Use salt and food high in salt sparingly.

ii. USDA Food Guide Pyramid

The USDA/DHHS developed the Food Guide Pyramid as a tool to illustrate concepts of dietary guidelines and to assist consumers in making healthy food choices every day. The pyramid encourages daily consumption of a variety of foods from each of six food groups within recommended ranges. A food intake of less than the recommendations of the Food Guide Pyramid for each group is considered insufficient; an intake equal to the recommendations is considered adequate; and an intake higher than the recommendations is considered excessive (with the exception of vegetables and fruits) (Goa *et al.*,2006:1341).

Figure _____________: USDA Food Guide Pyramid (USDA: online)

2.4.5.5 Lifestyle factors

Since overweight/obesity is viewed as a multi-faceted problem (Schwarz *et al.*, 2011:7), research proposes several different lifestyle and socio-behavioural factors that may be modified in order to contribute to weight reduction.

2.5.4.1 Physical activity levels

There are three categories of physical activity recommendations. These are to reduce the risk of chronic disease in adulthood, 30 minutes of moderate-intensity physical activity on most days of the week is recommended (ADA, 2009:336).

To help manage body weight, and prevent weight gain in adulthood, an individual should engage in 60 minutes of moderate- to vigorous-intensity exercises on most days of the week (ADA, 2009:336). According to Kruger *et al.* (2005:496) a combination of resistance training as well as aerobic exercise, 45 – 60 minutes on most days is needed to optimize the reduction of visceral adiposity.

To prevent weight regain (after weight loss), 60 – 90 minutes of daily moderate-intensity-activity, is recommended (ADA, 2009:336).

Overweight/obese people are advised to walk, when possible, rather than use their cars or public transport, to climb stairs rather than use the elevator and to take up one or more hobbies demanding physical exercise (Lokuruka, 2013:7096).

Regular physical activity is critical to overall physical and mental health, physical fitness, and to achieving and maintaining a healthy weight. Physical activity can help to control weight through an increase in energy expended (Schwarz *et al.*, 2011:12). Exercise also has positive effects on insulin and ghrelin (Schwarz *et al.*, 2011:12). Furthermore, it is essential to the development of strong bones, muscles, and cardiovascular health in children, and to maintain that foundation in adults and older adults. Physical activity also a protects against depression, which is commonly associated with overweight/obesity (Schneider *et al.*, 2012: 517358).

Under normal circumstances physical activity accounts for 15% to 30% of total energy expenditure (Lysen & Israel, 2012:465). Adequate levels of physical activity are 60 to 90 minutes daily, as recommended by USDA (Lysen & Israel, 2012:477). There is, however, evidence that, even if an overweight/obese adult is unable to achieve this level of activity, significant health benefits can be realised by participating in at least 30 minutes of daily activity of moderate activity (Lysen & Israel, 2012:477). Both aerobic and resistance training are recommended as part of any lifestyle or behaviour program aimed at weight loss (Schwarz *et al.*, 2011:15).

Energy expenditure is determined by the amount of oxygen metabolized by the body. Metabolic equivalents (METs) are units of measure that corresponds to a person's

metabolic rate during selected physical activities of varying intensity. Physical activity level (PAL) values for various activities performed throughout the day can be determined by adding the PAL for each activity. PAL lifestyle categories are sedentary, low active, active, active and very active (Haskell *et al*., 2007:1081).

PAL in populations is commonly assessed with the International Physical Activity Questionnaire (IPAQ) which was developed to serve as an international measure for physical activity in order to enable researchers to compare findings between different populations. In 2000 that the IPAQ became recognized as an acceptable measure of physical activity for use in many different settings and in different languages, and thus a suitable tool for national population-based prevalence studies of participation in physical activity (Booth, 2000: 114).

2.5.4.2 Television watching

Increases in time spent watching television (per hour per day), have been independently associated with weight gain (Mozaffarian *et al*., 2011:2396). Conversely, in a sample of older adults, decreased time watching TV was associated with significant lower risk of being overweight/obese, independent of meeting physical activity guidelines (Inoue *et al*., 2012:50). The time that is spent in front of the TV represents time not spent on physical activity; while it increases exposure to advertisements for high-fat, energy dense foods; and contribute to snacking, as TV watching is often combined with eating (Shields, 2009:143). Some studies have found that TV watching seems to lower resting metabolic rates to even lower than when asleep (Shields, 2009:143). TV watching for longer than 840 minutes per week has been defined as a risk factor for overweight/obesity (Inoue *et al*., 2012:51).

Several research studies support the finding that each hour of additional television time corresponds to a two to six per cent increase in a child's likelihood of being overweight/obese (The New Mexico [NM] Plan to Promote Healthier Weight 2006 – 2015). The American Academy of Pediatrics, together with the TV-Turnoff Network, an organization that encourages children and adults to watch less television in order to promote healthier lives and communities, recommends no screen time for children under two years of age and limiting older children's media and screen time to no more than two hours daily (The NM Plan to Promote Healthier Weight 2006 – 2015).

TV watching also causes people to eat significantly more, even if they are not physically hungry. One of the mechanisms by which TV watching may induce one to eat more, is through causing the brain to monitor external non-food cues such as the TV screen instead of the internal food cues that tell a person that one has eaten enough and must stop eating (Cooper *et al.*, 2006: 112). Sigman (2007: 13) states that humans tend to salivate unnaturally if their eating is distracted. These observations occur at time when 75% of the meals are eaten in front of the TV, causing one to eat more than usual when eating watching TV.

For adults a relatively active lifestyle can be defined as <10 hours/week of TV watching and > 30 minutes/day brisk walking (Hu *et al.*, 2012:1790).

2.5.4.3 Smoking

Smoking is generally associated with lower body weight and thus many people, particularly women, believe that smoking will help lower appetite and assist in weight loss or weight maintenance (Smolin and Grosvenor, 2008: 626). There are studies showing that smoking is inversely associated with weight gain (Mozaffarian *et al.*, 2011:2396). Smokers often resist quitting for fear of gaining weight, and indeed, studies have found that about 4.5 kilograms of weight is gained during the first year after quitting smoking,. Some studies have also found that smokers have consume more total and saturated fat, and fewer fruits and vegetables, and therefore fibre, than nonsmokers (Smolin and Grosvenor, 2008: 626).

2.5.4.4 Alcohol consumption

Increases in alcohol use are positively associated with weight gain (Mozaffarian *et al.*, 2011:2396). Alcohol accounts for 5.6% of the energy intake in the average US diet and has an energy value of 29 kJ/ml (Wang *et al.*, 2010:453). Habitual consumption of alcohol in excess of energy needs favors lipid storage and weight and thus contributes to overweight/obesity (Janssen *et al.*, 2001: 225). On the other hand; some studies show that compared to nondrinkers, initially normal-weight women who consume a light to moderate amount of alcohol, gained less weight and had a lower risk of becoming overweight/obese during 12.9 years of follow-up (Wang *et al.*, 2010:453).

2.5.4.5 Sleeping

Short sleeping duration is another independent factor associated with overweight/obesity (Schwarz *et al.*, 2011:13; Chaput *et al.*, 2009:1965; Patel & Hu, 2008:643). Compared to women who slept seven to 7.9 hours per night, women who slept an average of less than six hours per night in the recent past, had significant greater odds of being overweight/obese (Anic, 2010:447). Shortened sleep alters the endocrine regulation of hunger and appetite. Hormones that affect appetite take over and may promote excessive energy intake. Thus recurrent sleep deprivation can modify the amount, composition, and distribution of food intake and may contribute to the obesity pandemic (Lysen & Israel, 2012:469). Chronic partial sleep deprivation causes feelings of fatigue which may lead to reduced physical activity, as well as hormonal effects that increase kilojoule intake (Patel & Hu, 2008:643). There is also a link between sleep, disrupted circadian rhythm, genes, and the metabolic syndrome (Lysen & Israel, 2012:469).

According to Vorona *et al.* (2005:25) sleeping less than six hours per night and remaining awake beyond midnight increases the likelihood of overweight/obesity (Vorona *et al.*, 2005:25). Sleep duration has a U-shaped association with weight gain, with greater weight gain occurring with less than 6 hours or more than 8 hours of sleep per night (Mozaffarian *et al.*, 2011:2396). Increasing sleep duration could be a valid approach to weight control with or without energy restriction (Schwarz *et al.*, 2011:13). However research is limited and more studies are needed.

In another study however, sleep duration was not associated by BMI, overweight or obesity in women (Meyer *et al.*, 2011:1280).

2.5.4.6 Sun light exposure

Low vitamin D status is highly prevalent worldwide and the major determinants are sun exposure and vitamin D intake (Lukaszuk *et al.*, 2012:229; Palacios *et al.*, 2012:35; Ardawi, 2011:464). There is an increasing recognition and treatment of vitamin D deficiency even in countries from the Southern hemisphere. Historically, vitamin D deficiency has been more prevalent in homebound elderly individuals, hospitalized patients, and persons with a darker skin color who have a nutritional deficiency or gastrointestinal malabsorptive conditions (Stratton-Loeffler *et al.*, 2012:498). This perception is changing, as the number of people having vitamin D

deficiency increases. The Institute of Medicine (IOM) (US) has recently increased the recommended daily allowance (RDA) for Vitamin D from 200 to 600 IU for individuals aged 1 – 70 years (Lukaszuk *et al.*, 2012:229). To further complicate the vitamin D dilemma it was found that obesity is associated with increased requirements for vitamin D, or that low vitamin D may even predispose to obesity (Macdonald, 2013:163).

Vitamin D is referred to as the “sunshine” vitamin (Macdonald, 2013:163). Exposure of skin to sun is the only reliable mechanism for the body to synthesize its own vitamin D (Lukaszuk *et al.*, 2012:230). However there is concern about the cancer risks of UV radiation from excessive sunlight exposure. Advice has therefore been to cover up to avoid sunlight exposure, leading to some groups not getting enough vitamin D. The main point is not to avoid the sun completely, but take care not to burn. However this approach is still being debated by opposing groups: on the one hand, by evidence showing that even small amounts of sun may be damaging and, on the other hand, that we cannot obtain enough vitamin D with current lifestyles. There are many who advocate limited sunlight exposure to make enough vitamin D.

An English study suggest exposing one-quarter of the body surface (e.g. the hands, face, and arms) to summer sunlight in the United Kingdom two to three times a week for up to ten minutes (longer for darker skins) and then the skin should be protected from further sunlight exposure in order to make on average 1000 IU vitamin D per day, which should be sufficient to last the winter months. A 1000 IU of vitamin D represents four times the amount of vitamin D in 100g of oily fish. It is suggested that sunlight accounts for 90% of vitamin D and diet only ten per cent (Macdonald, 2013:163).

Another study states that exposing five per cent of the body surface in fair-skinned individuals two to three times a week for five minutes at noontime in the summer sun is equivalent to an intake of 430IU/day of vitamin D (Thieden *et al.*, 2005:1542) which satisfies the recommended vitamin D intake. Vitamin D occur naturally in fatty fish, egg yolks, fish liver oils (Lukaszuk *et al.*, 2012:232). Unfortunately these are not foods many people often eat. To supplement vitamin D may not be as effective as dietary intake or sun exposure, and may even be toxic in high doses (Macdonald, 2013:163).

Currently no validated, reliable, multi-item vitamin D screening tool exists that is intended for self-administration in community health/wellness settings (Lukaszuk *et al.*, 2012:230) and the assessment of vitamin D [as serum 25(OH)D] requires a blood test.

Serum 25-hydroxivitamin D [25(OH)D] level is the best indicator of vitamin D status (Ardawi, 2011:464) and there is an inverse relationship between 25(OH)D and both BMI and fat mass (Lukaszuk *et al.*, 2012:230). Overweight/obese persons usually have an inadequate vitamin D status (Ardawi, 2011:472; Rodriguez-Rodriguez *et al.*, 2009:778; Thieden *et al.*, 2005:1542). As people receiving low levels of sun exposure may have a vitamin D deficiency (Macdonald *et al.*, 2008:996), this raises the question whether there may be a link between overweight and levels of sun exposure?

Although it is clear that sunlight is important for vitamin D synthesis, it remains a challenge to recommend the appropriate sun exposure to produce sufficient vitamin D and minimize skin cancer risk. For those who do not get any sunlight, there continues to be uncertainty about the optimal dose and whether this differs according to population group or geographic location (Macdonald, 2013:163).

The length of time that skin needs to be exposed to the sun in order to obtain adequate exposure for sufficient production of vitamin D, depends on solar elevation angle (time of day and latitude), as well as atmospheric conditions.

2.5.4.7 Hobbies

One potential means for increasing the understanding of the factors required for successful weight maintenance is to study individuals who have been successful at losing weight and keeping it off. Data from these dieters possess coping skills that enable them to respond to cravings or stressful situations in ways that maintain their diets. In a descriptive study done by Klem *at al.* (1997:244) there was an improvement in the following areas as a result of weight loss: interactions with same- and opposite-sex friends and strangers, time spent interacting with others, job performance, and hobbies (Klem *et al.*, 1997:244). As boredom is an emotional stimulus to overeating (leading to overweight/obesity) (Hamburger, 1997:164) it raises the question if a person engages in a hobby it can possibly help to prevent obesity.

2.5.4.8 Religious service attendance

Ayers *et al*. (2010:563) found that religion may help prevent overweight/obesity. Religion has been associated with good physical health and may represent a protective factor against overweight and obesity (Dodor, 2012:451). Another study among college women found that spiritual well-being was negatively associated with emotional eating and environmental eating (thus preventing overweight/obesity) (Hawks, 2003:30). Koenig *et al*., (2001:381) also found religious activities to be an independent risk factor for the development of overweight/obesity; suggesting religious activities may help participants cope better with stress and to lowers depression, anxiety, and the need for consumption of comfort foods, tobacco, alcohol, or other drugs.

Many people attend religious services and belong to religious organizations because they feel it is important to their well-being and helps them feel a stronger connection to their community (Clark, 2000:26). Religious activities help people establish social networks and friendships which contributes to social well-being. Regular attendance at religious services is defined as attending at least once a month (Clark, 2000:23).

2.5.4.9 Social functioning

Overweight/obesity also creates other social and psychological problems (in turn contributing to even more weight gain). Overweight/obese women have been found to stay single, have lower incomes and complete fewer years of school (Sargent & Blanchflower, 1994:686). Overweight/obese individuals were also found to be more subject to stigmatisation, prejudice, and discrimination against with regard to employment and promotion opportunities (Ali & Lindström, 2005:327; Kruger *et al*., 2005:492), education (Tzotzas, 2010:732), income and even friendships (Ball, Crawford & Kenardy, 2004:1019). Being overweight/obese may also have a lasting effect on women's life satisfaction and their future life aspirations. They are found to be more dissatisfied with work/career/study, family relationships, partner relationships, and social activities (Ali & Lindström, 2005:327; Ball, Crawford & Kenardy, 2004:1019). In turn, all these problems may lead to more overeating, overweight/obesity; creating a vicious cycle.

Family functioning (as a form of social functioning) is associated with overweight/obesity in childhood (Wen *et al.*, 2011:1252). A mother who has herself experienced poor parenting or an impoverished environment as a child, may in turn have less capacity to influence both healthy family functioning and healthy lifestyle behaviours as an adult (Wen *et al.*, 2011:1256). Family functioning generally refers to interactions with family members that involve physical, emotional, and psychological activities and affects many aspects of family life, including acceptance of individuals, consensus on decisions, communication, and the ability to solve day-to-day problems (Wen *et al.*, 2011:1252). Unhealthy family functioning includes avoiding discussing concerns of fears, having negative feelings within the family, not being able to turn to each other for support or to confide in each other, not being able to talk about sadness or express feelings to each other, having difficulty in making decisions, not accepting family members as they are, and having difficulty in planning family activities (Wen *et al.*, 2011:1253).

Overweight/obese women are at higher risk of poor psychological health (Ali & Lindström, 2005: 327; Ball, Crawford & Kenardy, 2004:1020). Documented theories imply that being overweight/obese is distressing because it is viewed negatively by society. These negative evaluations are internalized as self-rejection because people view themselves as others see them. Compared to people of normal weight, overweight individuals may suffer from low self-esteem; have negative self-images; and think others dislike them (Ross,1994:64). Overweight/obesity is therefore associated with high levels of depression (Ross,1994:64; Luppino *et al.*, 2010:220; Zhao *et al.*, 2011:130). Adults with current depressive symptoms or with a lifetime diagnosis of depression or anxiety are more likely to be overweight/obese than adults without either disorder (Luppino *et al.*, 2010:220; Strine *et al.*, 2008:127). Among overweight/obese individuals, the female gender has been consistently associated with an increased risk of depression, suggesting that overweight/obesity and depression may be linked by gender-specific mechanisms (Ma & Xiao, 2010:347).

A person's history of physical, sexual or emotional trauma can also greatly affect weight status for individuals in complicated direct and indirect ways. These factors are included in what are sometime known as Adverse Childhood Experiences (ACEs), and have been studied for their relationship to later risky behaviour, poor

health outcome, and the development of numerous chronic conditions, including obesity (The NM Plan to Promote Healthier Weight 2006 – 2015).

2.5.4.11 Emotional eating

During stressful conditions approximately 40% of people eat more food, 40% consume less food, and 20% did not alter their eating patterns (Schwarz *et al.*, 2011:14).

2.5.4.12 Depression

Overweight/obese individuals report that stress and depressive symptoms can contribute to unhealthy dietary patterns, which may lead to further weight gain and abdominal obesity (Chambers & Swanson, 2006:79). Eating has been recognized as a coping mechanism for alleviating and dealing with stress and emotions (Schneider *et al.*, 2012: 517358; Ozier *et al.*, 2008:49). Furthermore individuals who eat in response to emotions and stress, are more likely to be overweight/obese (Ozier *et al.*, 2008:54; Blair, Lewis & Booth,1990:151). Concurrently, individuals who decreased their emotional eating, lost substantially more weight than those who did not decrease their emotional eating (Ozier *et al.*, 2008:54). Therefore it is important to screen for emotional eating, and address the problem, for lifestyle intervention strategies to be successful.

Stress can contribute to obesity (Lysen & Israel, 2012:469). Cortisol is released under stress; it stimulates insulin release to maintain blood glucose levels in the "fight-or-flight" response. Thus an increase in appetite occurs (Lysen & Israel, 2012:469).

Depression is highly comorbid with obesity and may impede weight loss treatment (Schneider *et al.*, 2012: 517358). There is some evidence of a relationship between vitamin D and the presence of depression during autumn and winter (Lukaszuk *et al.*, 2012:233).

2.5.4.13 Addictive eating behaviour

Another socio-behavioural factor that can contribute to overweight/obesity is the presence of addictive behaviour. Research suggests that eating is commonly used

as a method of self-drug in response to negative emotional states, such as depression, anxiety, loneliness, boredom, anger, and interpersonal conflict (Taylor Curtis & Davis, 2010:327). There is increasing agreement that excessive food consumption has many similarities to addictive behaviour (Nijs & Franken, 2012:107) and addiction disorders such as drug/alcohol abuse (Corwin & Grigson, 2009: 618; Pelchat, 2009:620; Gibson, 2006:53). This is partly due to the fact that overeating similarly to other addictive behaviour, activates the same brain reward mechanisms (Davis, 2009:549). Therefore, highly palatable foods may produce pleasure and reduce pain in a manner similar to other addictive substances (Taylor, Curtis & Davis, 2010:327). Unfortunately both food and drugs induce tolerance over time, whereby increasing amounts are needed to reach and maintain intoxication or satiety (Taylor, Curtis & Davis, 2010:327). Furthermore, the reward system implicated in drug addiction (Nijs & Franken, 2012:106), may play a role in overeating. Similar to addiction, the attention bias to rewarding foods might play an important role in the development and maintenance of overeating behaviour and weight gain/obesity (Nijs & Franken, 2012:107). Unfortunately the generally high-fat/high-sugar foods associated with Westernized environments are abundantly available, highly rewarding and are also advertised aggressively (Nijs & Franken, 2012:106).

People may benefit from a non-dieting approach to healthy weight management by encouraging and supporting healthy eating behaviours, promoting a positive body image, and limiting negative weight talk. Whenever possible, obesity prevention and treatment interventions should involve the family and other supportive social networks Females with higher levels of breakfast and dinner consumption frequency during adolescence were protected against becoming overweight later in life (Quick *et al.*, 2013:48).

Behavioural and psychological interventions can be divided into: interventions concerned with self-monitoring of behaviour and progress; identification of and avoidance of triggers that prompt unwanted behaviour, in particular unplanned eating (stimulus control); modification of unhelpful thoughts and thinking patterns into helpful ones (cognitive restructuring). Particular behaviours that been focused on include goal setting, problem solving, assertiveness training, securing social support and a slowing of the rate of eating. Changes in behaviour in line with such strategies

can lead to a reduction in energy intake or an increase in energy expenditure, ultimately leading to weight loss (Hankey, 2010:36).

The use of behavioural therapy is intended to help the individual to identify those signals that trigger inappropriate behaviour both as regards eating and physical activity, and to learn afterwards to develop new responses in the face of these signals (Garaulet & de Herdia, 2010:11). The proper control of body weight will not depend on willpower, but on the development of skills that will lead them to "normalise" their relation with food (Garaulet & de Herdia, 2010:11).

Different techniques, summarized in Table___, are used in behavioural therapy, such as stimulus control, self-monitoring, positive reinforcement, or cognitive restructuring (Garaulet & de Herdia, 2010:11).

Table 2: Techniques used in behavioural therapy for obesity treatment (Garaulet & de Herdia, 2010:11):

Technique:	**Application:**
Stimulus control	Restricting the number of places where eating is permitted, eating slowly, not skipping meals, keeping palatable food in opaque containers, etc.
Self-monitoring	Daily log of food consumed and exercise taken.
Positive reinforcement	New clothes, or small gifts, or prizes when the aimed weight is reached.
Cognitive restructuring	Substituting negative and self-destructive thoughts by positive and stimulating ones.
Prevent relapses	Identifying "slips" and how to avoid them.

2.5.6 Medical treatment of overweight/obesity

Drugs and surgical treatments are potentially available to those unable to implement lifestyle interventions effectively by achieving losses of between 5kg and 10kg (Hankey, 2010:34).

2.5.6.1 Pharmacotherapy

Pharmacotherapy is only indicated for people with a BMI > 30kg/m² (ADA, 2009: 330). Specific anti-obesity drugs may be effective adjuncts to weight loss, in some cases doubling the weight loss compared to those only receiving dietary advice (Hankey, 2010:34). Drugs that are licensed for obesity treatment include sibutramine and orlistat. Sibutramine is a re-uptake inhibitor of both serotonin and noradrenaline and affects a feeling of fullness. Orlistat reduces the absorption of dietary fat by inhibiting pancreatic lipases (Hankey, 2010:37). To be effective, both these drugs require patient input and compliance to healthy dietary and lifestyle adaptations and therefore dietary advice is advocated with both drugs (Hankey, 2010:37). Both are highly scheduled drugs in most countries. Orlistat, however, is available over the counter in some countries, but at a dose half that examined in clinical trails (60mg) (Hankey, 2010:37).

A number of other drugs have been used and studied as potential aids in weight loss. Amphetamine and its derivatives, which are psychomotor stimulants and have anorectic actions, have also been used as "slimming agents". These drugs may aid people to adhere to their diets (Lokuruka, 2013:7097), but they are not legal for weight loss (Roelen *et al.*, 2014:78) (Roelen *et al.*, 2014:78). Thyroxide stimulates metabolism and therefore has had extensive trails in the treatment of obesity. However, because it is contraindicated, except in those cases where obesity is associated with evidence of hyperthyroidism, it is not recommended for obesity treatment (Lokuruka, 2013:7097). Diuretics are potentially dangerous, but may be useful where a person has oedema arising from cardiac failure or other organic disease (Lokuruka, 2013:7097). Victoza is a diabetic drug widely used for weight loss, but it is done unlicensed (Marre *et al.*,2009:268). Other drugs and materials which though available (often by non-subscription) for overweight/obesity treatment are not effective include ephedrine, chitosan, St. John's wort, hydroxycitric acid, herbal laxatives and diuretics, appetite depressants, and 5-hydroxytryptophan (Lokuruka, 2013:7097).

2.5.6.2 Surgical procedures

For those people who are unable to implement lifestyle advice to control their body weight surgical treatment may be the only effective treatment. In all cases surgical treatments can be suitable for patients for whom all other options, including pharmacotherapy, have been unsuccessful (Lokuruka, 2013:7097; Hankey, 2010:37).

Various forms of jejuno-ileostomy which by creating a bypass of the small intestine, lead to malabsorption, have been tried. Following this procedure, food intake often has oftn to be reduced to prevent flatulence and abdominal discomfort. The operation seems unphysiological and carries a mortality rate of about 4%. Due to complications related to malabsorption and the blind loop syndrome, such operations are seldom carried out.

Operations to reduce the size of the stomach seems safer and less unphysiological than those that restrict access of food to the small intestine. Gastroplasty is an operation in which the stomach is reduced to a small reservoir, about 60mL in capacity, in the fundus, which drains through a narrow channel, about 12mm in diameter, along the greater curvature and into the duodenum (Lokuruka, 2013:7098). The vertical banded gastroplaty-Roux-and-Y gastric bypass technique, is a preferred operation in weight loss surgery (Lokuruka, 2013:7098). The application of adjustable gastric bands seems more humane and physiologically tolerable than the practically irreversible resection and by-pass operations.

Weight losses of between half and three-quarters of excess body weight are seen at 10 years post intervention with bariatric surgery, making this the most effective weight-loss treatment (Hankey, 2010:34). Surgical procedures not only produce weight loss, but also reduce secondary abnormalities (DeMaria, 2013:785).

Liposuction to remove masses of fat from the stomach, thighs and arms is contraindicated; the appearance of irregular and ugly lumps of fat at the operation sites has been observed (Lokuruka, 2013:7098). It is, however, not usually a weight-reduction technique, but a cosmetic surgery (because only a small amount of fat is

removed at a time). Deaths, severe infections, cellulitis, and hemorrhage have occurred from liposuction (Israel & Lysen, 2012:482).

2.5.8 Supportive public health measures

Governments have several options for addressing the obesity epidemic. They can conduct public health campaigns, use the mechanism of taxes, or eliminate the sale of certain products. Legislative action can be directed to the food suppliers or to the public (DeMaria, 2013:785). A significant difference can be made if governments put in the same kind of organised effort into fighting overweight/obesity, as for smoking (DeMaria, 2013:785).

2.5.4 Conclusion

CHAPTER 3:

METHODOLOGY

3.1 Introduction

This study assessed the lifestyle and environmental risk factors associated with overweight/obesity in white women living in the Lejweleputswa district, South Africa. This chapter describes the ethical considerations, study design, study population, sampling methods, variables and work definitions, as well as the methodology and techniques used for the execution of the study. The study procedures and the methods used in statistical analysis of the results are included.

3.2 Ethical approval

Ethical approval was obtained from the Ethics Committee of the Faculty of Heath Sciences of the University of the Free State (ETOVS nr 37/2013). This study utilised a self-reporting questionnaire. In order to ensure that the study was ethical, a detailed consent form, including an explanation of the purpose of this study and the procedures that would be followed in the study, appeared as the first visible page of

the questionnaire. If participants signed the consent form and moved on to answer the questionnaire, their informed consent was assumed.

The consent form explained that participation in the study was voluntary, and all information gathered would only be used for the purposes of this study, and would be kept strictly confidential. The form also explained that participation would assist the development of better weight loss strategies; that there would be no costs to participants, but also that no compensation would be given for participation; that the participants were under no obligation to participate in the study; that they had the right to withdraw their participation at any point during the study; and that the study may be published, but without identifying the subjects. Each participant received a cold fruit juice as a token of appreciation for participating in the study.

3.3 Study design

A descriptive observational study was conducted.

3.4 Study population and sampling

Lejweleputswa is one of the five districts that constitutes the Free State province of South Africa. According to the latest available statistics at the time of the data collection, Lejweleputswa had an estimated population of 627 626 people (Census 2011, Statistics South Africa: 2001: Online). The Afrikaans speaking population constituted 11.4% and the English speaking population 3.1%. Half of the population (50.7%) were female, and 8.6% were white (Census 2001, Statistics South Africa). Using these statistical information, the study population of white females in the rural Lejweleputswa district were estimated at around 8 000.

Convenience sampling of white women, aged 18 years and older, who resided in the Lejweleputswa district at the time of the study, was conducted in four different locations.

The national maize producers organization (NAMPO) is SA’s largest agricultural event and is held annually in this specific area. Nampo is a platform enabling agricultural producers to be exposed to new trends in farming and at the same time it also serves as a display window for agriculture, a discussion forum and a network opportunity for role-players in agriculture in SA and further afield. The people visiting NAMPO are mostly farmers from surrounding towns (Hendriks, 2011:1), thus at large representing the rural white population of the district. To obtain a convenient sample for the research study, the researcher collected data at the women’s market, held next to NAMPO in Bothaville. Over four days at NAMPO, a single researcher and three trained field workers, approached women attending the women’s market to invite them to participate in the study and, if they gave consent, collected data.

To be able to include women from all of the Lejweleputswa area, additional data collection was conducted on three different days at Free State Women’s Agricultural

Union meetings held in Welkom, Theunissen, and Hoopstad. All the women attending these gatherings, were invited to participate in the study.

There was a total of seven days of data collection from nine a.m. to four p.m. with an hour break per day. Respondents were randomly approached and invited to participate in the study (asking for about twenty to thirty minutes of their time). Where they came from was used as a screening tool. People coming from outside of Lejweleputswa were not invited to participate in the study.

It was anticipated in the protocol that with six hours of data collection over seven days, and approximately 30 minutes to complete the questionnaire and the anthropometric measurements on each respondent, it would be possible for the researcher and three field workers to collect data on 336 women. In the end this was not possible, as it turned out to be very difficult to convince people to participate in the study.

3.5 Measurements: variables and work definitions

For the purpose of this study socio-demographic variables, anthropometry, usual dietary intake, physical activity levels and socio-behavioural variables were assessed.

3.5.1 Socio-demographics

Socio-demographics referred to age, district of residence, marital status, occupation, level of education, and socio-economic status.

3.5.2 Anthropometry

Anthropometric assessment provides a fast, inexpensive method of assessing the body composition and size (Gibson, 2005: 10). For the purpose of this study anthropometry referred to various indices of body fatness, assessed by BMI and BAI, as well as measures of abdominal/trunkal fatness, namely WC, WHR and WtHR, which are all closely associated with the risk for NCDs.

3.5.2.1 BMI

BMI reflects body fatness by expressing the body weight in relation to height squared, independently of the frame size of the subject (Klisiewics & Raal, 2009:14; Kyrou & Tsigos, 2009:S406). BMI values were interpreted according to WHO (2004) classification (Table 1)

Table 3.1: Categorisation of BMI in males and females 18 years and older (Mitchell *et al.*, 2011:718)

Weight	**BMI (kg/m^2)**
Underweight	<18.5
Normal	18.5 – 24.9
Overweight	25.0 – 29.9
Obesity	30.0 – 39.9
Extreme obesity	>40.0

3.5.2.2 BAI

Bergman *et al.* (2011: 1083) found that, compared to dual-energy X-ray absorptiometry (DXA), body adiposity index (BAI), provides an accurate measure of body fatness. BAI estimates body fat percentage directly based on height and hip circumference (HC), according to the following formula:

$$BAI\ (\%\ body\ fat) = HC\ (cm) / Height\ (m)^{1.5} - 18$$

BAI was interpreted according to the levels of body fat percentage recommended for females (Ricciardi *et al.*,2009:4):

Low level of body fat:	14-20% in females;
Average level of body fat:	21-25% in females;
Above average level of body fat:	26-29% in females;
Overweight level of body fat:	30-35% in females; and
Obese level of body fat:	>36% in females.

3.5.2.3 WC

WC was measured midway between the top of the superior iliac crest and the lowest rib in the mid axillary line. WC was interpreted according to the WHO guidelines as at increased risk for metabolic complications at a cut-off point of ≥80cm (Alberti *et al.*, 2009: 1640) and at substantially increased risk for metabolic complications at a WC of ≥88cm (SASSO, 2003: online).

3.5.2.4 WHR

The WHR was calculated, based on WC divided by the hip circumference (Goh *et al.*, 2014:1). The cut-off point of 0.8 was used. Women with a WHR above this cut-off point are at increased health risk (ADA, 2000:16).

3.5.2.5 WHtR

WHtR refers to waist circumference in cm divided by height in cm. A universal cut-off of WHtR ≥ 0.5 indicates a greater risk of metabolic syndrome and cardiovascular disease in both genders and in individuals of all ages (Savva *et al.*, 2013:406).

3.5.3 Dietary intake

For the purpose of this study dietary intake referred to usual daily food intake, frequency of meal consumption, and the frequency with which specific foods were reported to be consumed on a daily, weekly or monthly basis.

The usual daily food intake of participants was assessed by comparing intake to the USDA/DHHS FGP.

The USDA/DHHS FGP (Figure 1) is a tool used to illustrate concepts of dietary guidelines to assist consumers in making daily healthy food choices. The pyramid encourages daily consumption of a variety of foods from each of six food groups, within recommended ranges. For the purpose of this study the food choices in each of the food groups were adapted to reflect South African foods typically consumed by the white rural community in the study area.

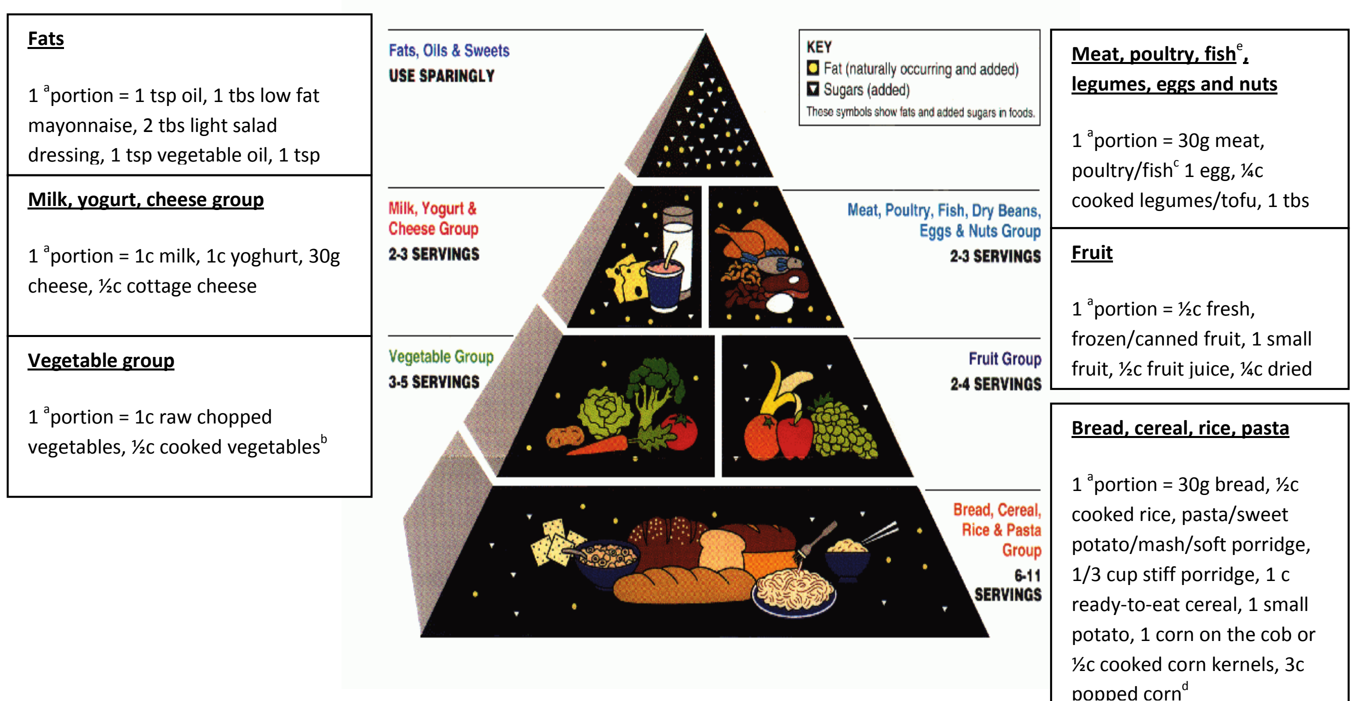

Figure 1: USDA Food Guide Pyramid (USDA: online) adapted for this study

a. For the purpose of this study "servings" were referred to as "portions", as in the experience of dieticians, this term is generally better understood by the South African public.
b. According to dietary guidelines for Canadians this should include at least one green leafy vegetable and one orange vegetable per day (Escott-Stump & Earl, 2008:342).
c. Although a portion of meat is technically equal to 30g (matchbox size) based on its macronutrient content, dieticians find that the South African public finds it hard to relate to such a small portion. For the purpose of this study responders were asked how many "edible portions" of 90g each (thus as big as a deck of cards) they can eat per day (but the data will be interpreted based in 30g portions).
d. According to dietary guidelines for Canadians at least half of these should be whole grain (Escott-Stump & Earl, 2008:342).
e. According to dietary guidelines for Canadians 2 x 90g portions of fish should be consumed weekly (Escott-Stump & Earl, 2008:342).

An intakes of less than the recommendations of the FGP for a specific food group was considered insufficient; an intake equal to the recommendations was considered adequate; and an intake higher than the recommendations was considered excessive (with the exception of vegetables and fruits for which specific recommended upper limits of intakes are not set) (Table 2).

The original FGP (figure 1) only recommends eating sugar and fats sparingly, without quantifying it. However, in 2005, the USDA/DHHS published recommendations that intakes of these two food groups in an average 8400kJ diet should be limited to less than 12 teaspoons of sugar (6 portions) per day and 41g of added fats (8 portions) per day (Dodd, 2008:278). The intakes of added sugar and added fats, were compared to these recommendations.

Table 3.2: Interpretation of usual diet according to the USDA FGP (Bonnie, 2004:304).

Food group/type	Interpretation of number of daily portions		
	Insufficient	***Adequate***	***High***
Grains	<6	6-11	>11
Vegetables	<3	3-5	*
Fruit	<2	2-4	*
Dairy	<2	2-3	>3
Meat, poultry, fish, legumes and nuts	<2	2-3	>3

Fat, oils	<5	6-7	>8
Added sugar	-	-	>6

* high levels of intake of vegetables and fruit were not interpreted as excessive, as evidence suggest that high intakes are beneficial.

The daily frequency and timing of meals, as well as the frequency with which particular foods from a list, adapted adapted to reflect food choices of white women in the Lejweleputswa district, were consumed on a daily, weekly or monthly basis, were also assessed.

3.5.4 Lifestyle Factors

For the purpose of this study lifestyle factors referred to physical activity levels, television watching behaviour, smoking and alcohol consumption.

3.5.4.1 Physical activity levels

For the purpose of this study physical activity was measured with the International Physical Activity Questionnaire (IPAQ). The IPAQ was developed as a tool for cross-national monitoring of physical activity and inactivity. Between 1997 and 1998, an International Consensus Group developed four long and short forms of the IPAQ tools. These tools were developed for administered by telephonic interview or self-administration, with two alternate reference periods, either the “last seven days” or a “usual week” to recalled physical activity. Overall, the IPAQ produced repeatable data with comparable data from short and long forms. The IPAQ was shown to have acceptable measurement properties for physical activities among 18 to 65-year-old adults in diverse settings – at least as good as other established self-reports. The original IPAQ was adapted to include examples of activities which are relevant to the study population, but with the same metabolic equivalents (MET)-values to quantify the physical activity levels. METs are units of measure that correspond to a person’s metabolic rate during selected activities and are expressed as multiplies of resting metabolic rate (RMR). A MET value of one is the oxygen metabolized at rest, which is 3.5 mL of oxygen per kilogram of body weight per minute in adults (1 MET = ~ 3.5 ml of O_2/kg/min), and can be expressed as 1 kcal per kilogram of body weight per hour (1MET = 1 kcal/kg/hour) (Institute of Medicine, 2002, 2005).

a. IPAQ categories

Activity levels obtained with the IPAQ were categorised according to three levels:

The “**high” active category** described higher levels of participation in physical activity. The IPAQ Research Committee proposes the following measure to equate that approximately one hour per day or more, of at least moderate-intensity activity

above the basal level of physical activity. Basal activity may be considered to be equivalent to approximately 5000 steps per day. It is proposed that the “high active” category be considered as those who move at least 12 500 steps per day, or the equivalent in moderate and vigorous activities. This represents at least an hour or more of moderate-intensity activity, or half an hour of vigorous-intensity activity over and above basal levels daily. These calculations were based on results from pedometer studies. This translates into vigorous-intensity activity on at least three days achieving a minimum total physical activity of at least 1500 MET-minutes, OR seven or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum total physical activity of at least 3000 MET-minutes/week (Craig *et al*., 2003:1383).

The “**moderate” active category** referred to three or more days of vigorous-intensity activity of at least 20 minutes per day OR five or more days of moderate-intensity activity and/or walking of at least 30 minutes per day OR five or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum total physical activity of at least 600 MET-minutes/week. Individuals meeting at least one of the above criteria were defined as accumulating a minimum level of activity and therefore classified as “moderate” active (Craig *et al*., 2003:1383).

The “**low” active category** was simply defined as not meeting any of the criteria for either “high” or “moderate” categories (Craig *et al*., 2003:1383).

The number of active days was also assessed and interpreted according to the following categories:

Less than five days

At least five days

At least seven days

b. MET Values and Formula for Computation of MET-minutes/week

Median values and inter-quartile ranges were computed for walking (W), moderate intensity activities (M), vigorous-intensity activities (V) and a combined total physical activity score. All continuous scores were expressed in MET-minutes/week and used to quantify levels of activity as follows:

Walking METs-minutes/week = 3.3 x walking minutes per week;
Moderate METs-minutes/week = 4.0 x moderate-intensity activity minutes per week; and
Vigorous METs-minutes/week = 8 x vigorous-intensity activity minutes per week.

Total physical activity MET-minutes/week = sum of Walking + Moderate + Vigorous MET minutes/week scores.

3.5.4.2 Television watching activities

The amount of time spent watching TV was assessed. As TV-watching for longer than 840 minutes per week has been defined as a risk factor for overweight/obesity (Inoue *et al*., 2012:51); for the purpose of this study, high television watching was defined as watching TV more than 840min/week (i.e. more than two hours per day, for seven days of the week) and low TV watching as up to 840min/week.

3.5.4.3 Smoking

For the purpose of this study, only habitual cigarette smoking was assessed. Smoking was classified according to the categories adapted from Russo *et al*. (2001:1403).

Table 3.3: Categorisation of cigarette smoking habits (Russo *et al*., 2001:1403)

Category	Number of cigarettes per day
Non-smoker	Never smoked
Light smoker	1-20
Heavy smoker	>20
Ex-smoker	Stopped smoking 1 year before the study

3.5.4.4 Alcohol consumption

For the purpose of this study, alcohol intake referred to the consumption of beer, wine, cider, spirits, whiskey, brandy and liqueurs. Alcohol consumption was interpreted according to the categories in Table 4, based on the recommended limit of seven units of alcohol per week for women (Evans, 2009: 215).

Table 3.4: Categorisation of alcohol intake of females (Evans, 2009: 215)

Category of alcohol units	Females
Non-drinker	0 units/day
Sensible drinker	1 unit/day
Maximum drinker	2 - 3 units/day

Other	More than 3 units/day

3.5.5 Socio-behavioural factors

3.5.5.1 Sleeping patterns

The number of hours of sleep was assessed. In accordance with Vorona *et al.* (2005:25), for the purpose of this study inadequate sleep was defined as less than six hours of sleep per night, while adequate sleep was defined as sleeping six or more hours per night.

3.5.5.2 Sun light exposure

The number of minutes of sunlight exposure was assessed. The length of time that skin needs to be exposed to the sun in order to obtain adequate exposure for sufficient production of vitamin D, depends on solar elevation angle (time of day and latitude), as well as atmospheric conditions. For the purpose of this study adequate sun light exposure was defined as five minutes of noontime sun light exposure two to three times per week. More than ten to 15 minutes of sun exposure per week were defined as excessive exposure, and less than ten to 15 minutes of sun exposure a week, as inadequate sun light exposure.

3.5.5.3 Participation in hobbies

The type of hobbies that the women engaged in, were assessed. For the purpose of this study hobbies referred to an activity or interest pursued for pleasure or relaxation and not as a main occupation.

3.5.5.4 Religious service attendance

Frequency of religious service attendance was assessed. For the purpose of this study regular religious service attendance were defined as attending a service at least once a month.

3.5.5.5 Social functioning

Social functioning for the purpose of this study referred to those factors included in the "Social Functioning Questionnaire (SFQ)". The SFQ was developed as a quick

assessment tool of perceived social functioning, and is recommended for research in epidemiological investigations. This questionnaire was chosen for the current study, as it assesses life satisfaction, and the latter has been found to be associated with overweight/obesity (Ali & Lindström, 2005:327; Ball, Crawford & Kenardy, 2004:1019). The SFQ is an eight-item self-reported scale (score range 0 – 24); a score of ten or more indicate poor social functioning (Tyrer *et al*. 2005:265). The SFQ consists of the following questions, with the score allocated for each answer indicated in brackets:

1. I complete my tasks at work and home satisfactorily:
   i. Most of the time (0)
   ii. Quite often (1)
   iii. Sometimes (2)
   iv. Not at all (3)
2. I find my tasks at work and at home very stressful.
   i. Most of the time (3)
   ii. Quite often (2)
   iii. Sometimes (1)
   iv. Not at all (0)
3. I have no money problems.
   i. No problems at all (0)
   ii. Slight worries only (1)
   iii. Definite problems (2)
   iv. Very severe problems (3)
4. I have difficulties in getting and keeping close relationships.
   i. Severe difficulties (3)
   ii. Some problems (2)
   iii. Occasional problems (1)
   iv. No problems at all (0)
5. I have problems in my sex life. (Respondents who are not sexually active, tick d] No problems at all)
   i. Severe problems (3)
   ii. Moderate problems (2)
   iii. Occasional problems (1)
   iv. No problems at all (0)
6. I get on well with my family and other relatives.
   i. Yes, definitely (0)
   ii. Yes, usually (1)
   iii. No, some problems (2)
   iv. No, severe problems (3)
7. I feel lonely and isolated from other people.
   i. Almost all the time (3)
   ii. Much of the time (2)
   iii. Not usually (1)

iv. Not at all (0)

8. I enjoy my spare time.
   i. Very much (0)
   ii. Sometimes (1)
   iii. Not often (2)
   iv. Not at all (3)

3.5.5.6 Emotional eating

Emotional eating for the purpose of this study referred to factors included in the "Three-Factor Eating Questionnaire (TFEQ)", which is a self-assessment scale widely used in studies on eating behaviour in overweight and normal weight individuals (Cappelleri *et al*. 2009:611). The TFEQ-R21 consists of 21 questions on a four-point response scale (definitely true/mostly true/mostly false/definitely false). Responses to each of the 21 questions are scored between one and four and question scores are summated into scale scores for cognitive restraint, uncontrolled eating, and emotional eating (Cappelleri *et al*. 2009:613). As this study was only concerned with emotional eating, only the six relevant questions were used. Before calculating the emotional eating domain's score, the questions were reverse coded.

The included question statements were:

1. I start to eat when I feel anxious.
2. When I feel sad I eat too much.
3. When I feel tense or "wound-up", I often need to eat.
4. When I feel lonely, I console myself by eating.
5. If I feel nervous, I try to calm myself by eating.
6. When I feel depressed I want to eat.

3.5.5.7 Depression

Depression for the purpose of this study, was assessed based on the prevalence of depressive symptoms as included in the "Patient Health Questionnaire – 9 (PHQ-9) diagnostic Algorithm" which has been shown to provide valid measurements of depression (Kroenke, Spitzer & Williams, 2001:607). Respondents were asked how often, over the previous two weeks, they had experienced each of the following symptoms:

1) little interest or pleasure in doing things;
2) feeling down, depressed, or hopeless;
3) trouble falling or staying asleep or sleeping too much;
4) feeling tired or having little energy;
5) having poor appetite or overeating;
6) feeling bad as a failure or having let themselves or their family down;
7) having trouble concentrating on things such as reading the newspaper or watching TV;
8) moving or speaking so slow that other people could have noticed, or being so fidgety or restless that they had been moving around a lot more than usual; and
9) having thoughts of suicide or self-injury in some way.

Participants were defined as having major depressive symptoms if they had at least five of the nine PHQ-9 criteria for more than (or equal to) nine days (or > several days for "having thoughts of suicide or self-injury") in the past two weeks, one of which must be "loss of interest or pleasure in doing things" or "feel down, depressed, or hopeless" for more than seven days in the past two weeks. Alternatively, participants' responses to each item were scored as 0 points for "not at all", one point for "having the symptoms for several days", two points for "having the symptoms for more than half the days", and three points for "having the symptoms for nearly every day". Their scores for each item were then added to produce a total depression severity score, as shown in Table 5, and the cut-off point of more than (or equal to) ten were used to identify participants as having moderate-to-severe depressive symptoms.

Table 3.5: Depression severity according to total PHQ-9 score (Kroenke, Spitzer & Williams, 2001:610)

Total PHQ-9 score:	**Depression severity:**
0-4	Minimal
5-9	Mild
10-14	Moderate
15-19	Moderately severe
20-27	Severe

3.5.5.8 Addictive behaviour

Addictive eating behaviour for the purpose of this study was assessed based on the variables included in the "Yale Food Addiction Scale (YFAS)" (Gearhardt, Corbin, &

Brownell, 2009:431). The YFAS translates the substance dependence diagnostic criteria outlined in the Diagnostic and Statistical Manual IVTR 12 to apply to eating behaviour. The YFAS provides two scoring options, a ‘‘symptom’’ count version that indicates the number of dependence symptoms experienced in the previous 12 months, and a ‘‘diagnostic’’ threshold that is met when three or more ‘‘symptoms’’ were present during the previous 12 months and clinically significant impairment or distress is endorsed. Given the frequent application of addiction-related terms to eating behaviour in popular culture, no mention of addiction is included in the scale content (Gearhardt, Corbin, & Brownell, 2009:432).

The YFAS11 is a 25-item self-report measure of addictive eating behaviours with high fat/sugar foods. People sometimes have difficulty controlling their intake of certain foods such as sweets, like ice cream, chocolate, doughnuts, cookies, cake, candy, ice cream; starches, like white bread, rolls, pasta, and rice; salty snacks, like chips, pretzels, and crackers; fatty foods, like steak, bacon, hamburgers, cheeseburgers, pizza, and French fries; and sugary drinks like soft drinks. Respondents were asked about the occurrence of eating behaviours during the previous 12 months that were analogous to the diagnostic criteria for substance dependence. Participants were given the instruction: ‘When the following questions ask about “CERTAIN FOODS” please think of ANY food similar to those listed in the food group or ANY OTHER foods you have had a problem with in the past year.’ The following questions were asked and the answering options were “four or more times or daily” (four points), “two to three times a week” (three points), “two to four times a month” (two points), and “once a month” (one point), and “never” (0 points):

1. I find that when I start eating certain foods, I end up eating much more than planned.

2. I find myself continuing to consume certain foods even though I am no longer hungry.

3. I eat to the point where I feel physically ill.

4. Not eating certain types of food or cutting down on certain types of food is something I worry about.

5. I spend a lot of time feeling sluggish or fatigued from overeating.

6. I find myself constantly eating certain foods throughout the day.

7. I find that when certain foods are not available, I will go out of my way to obtain them. For example, I will drive to the store to purchase certain foods even though I have other options available to me at home.

8. There have been times when I consumed certain foods so often or in such large quantities that I started to eat food instead of working, spending time

with my family or friends, or engaging in other important activities or recreational activities I enjoy.

9. There have been times when I consumed certain foods so often or in such large quantities that I spent time dealing with negative feelings from overeating instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoy.

10. There have been times when I avoided professional or social situations where certain foods were available because I was afraid I would overeat.

11. There have been times when I avoided professional or social situations because I was not able to consume certain foods there.

12. I have had withdrawal symptoms such as agitation, anxiety, or other physical symptoms when I cut down or stopped eating certain foods. (Please do NOT include withdrawal symptoms caused by cutting down on caffeinated beverages such as soft drinks, coffee, tea, energy drinks, etc.).

13. I have consumed certain foods to prevent feelings of anxiety, agitation, or other physical symptoms that were developing. (Please do NOT include consumption of caffeinated beverages such as soft drinks, coffee, tea, energy drinks, etc.).

14. I have found that I have elevated desire for or urge to consume certain foods when I cut down or stop eating them.

15. My behaviour with respect to food and eating causes significant distress.

16. I experience significant problems in my ability to function effectively (daily routine, job/school, social activities, family activities, health difficulties) because of food and eating.

17. My food consumption has caused significant psychological problems such as depression, anxiety, self-loathing, or guilt.

18. My food consumption has caused significant physical problems or made a physical problem worse.

19. I kept consuming the same types of food or the same amount of food even though I was having emotional and/or physical problems.

20. Over time, I have found that I need to eat more and more to get the feeling I want, such as reduced negative emotions or increased pleasure.

21. I have found that eating the same amount of food does not reduce my negative emotions or increase pleasure feelings the way it used to.

22. I want to cut down or stop eating certain kinds of food.

23. I have tried to cut down or stop eating certain kinds of food.

24. I have been successful at cutting down or not eating this kind of food.

25. How many times in the past year did you try to cut down or stop eating certain foods altogether?

The scale questions were grouped under specific criteria that resemble the symptoms for substance dependence as stated in the Diagnostic and Statistical Manual of Mental Disorders IV-R and operationalized in the Structured Clinical Interview for DSM-IV Axis I Disorders:
1) Substance taken in larger amount and for longer period than intended: Questions #1, #2, #3
2) Persistent desire or repeated unsuccessful attempts to quit: Questions #4, #22, #24, #25
3) Much time/activity to obtain, use, recover: Questions #5, #6, #7
4) Important social, occupational, or recreational activities given up or reduced: Questions #8, #9, #10, #11
5) Use continues despite knowledge of adverse consequences (e.g., failure to fulfill role obligation, use when physically hazardous): Question #19
6) Tolerance (marked increase in amount; marked decrease in effect): Questions #20, #21
7) Characteristic withdrawal symptoms; substance taken to relieve withdrawal: Questions #12, #13, #14
8) Use causes clinically significant impairment or distress: Questions #15, #16

Cut-offs
The following cut-offs were developed for the continuous questions.
0 = criterion not met, 1 = criterion is met
The following questions were scored 0 = (0), 1 = (1): #19, #20, #21, #22
The following question was scored 0 = (1), 1 = (0): #24
The following questions were scored 0 = (0 thru 1), 1 = (2 thru 4): #8, #10, #11
The following questions were scored 0 = (0 thru 2), 1 = (3 & 4): #3, #5, #7, #9, #12, #13, #14, #15, #16
The following questions were scored 0 = (0 thru 3), 1 = (4): #1, #2, #4, #6
The following question was scored 0 = (0 thru 4), 1 = (5): #25
The following questions were NOT scored, but were primers for other questions: #17, #18, #23

After computing cut-offs, the questions under each substance dependence criterion (e.g. Tolerance, Withdrawal, Clinical Significance, etc.) were summarized. If the score for the criterion is > 1, then the criterion has been met and was scored as 1. If the score = 0, then the criteria have not been met.

Example:
Tolerance: (#20 =1) + (#21 = 0) = 1, Criterion Met
Withdrawal (#12 =0) + (#13 = 0) + (#14 = 0) = 0, Criterion Not Met
Given up (#8 =1) + (#9 = 0) + (#10 =1) + (#11 = 1) = 3, Criterion Met and scored as 1

To score the continuous version of the scale, which resembles a symptom count without diagnosis, the scores for each of the criteria (e.g. Tolerance, Withdrawal, Use despite Negative Consequence) was added up. Clinical significance to the score was not added. This score should have ranged from 0 to seven (0 symptoms to seven symptoms.)

A diagnosis of substance dependence was made if the symptom count was >3 and items 15 and 16, which depicts clinical significance, equaled one (items 15 or 16 =1).

3.6 Measurements: Techniques

Data was obtained by a self-reported questionnaire (addendum A) to assess dietary intake, as well as socio-demographic data, lifestyle factors and socio-behavioural factors. Questions were formulated to include open and closed ended questions and the questionnaire was made available in English and Afrikaans. One researcher and three trained fieldworkers measured the participants' anthropometry and recorded it on the questionnaire.

3.6.1 Socio-demographics

This component included open and closed-ended questions in the self-administered questionnaire.

3.6.2 Anthropometry

Each respondent's weight, height, WC and HC were measured by a trained researcher. From these parameters BMI, BAI, WHR, and WtHR were calculated.

3.6.2.1 Weight

Weight was determined with a floor type, *Seca* 770, digital scale according to the standard procedures (Gibson, 2005: 247-252; Lee and Nieman, 2007:173). The scale was placed on a hard, flat surface and adjusted for zero-balance before each measurement. The participants wore minimal clothing (remove jacket, shoes, and jewellery) and stood still in the middle of the scale's platform without touching anything and with the weight equally distributed on both feet. Weight was recorded to the nearest 100g. To ensure reliability, the batteries for scales were changed every other day of usage, the scales were calibrated with a known weight (five kilogram bag of maize meal) at the beginning of the day and after every 20 readings, and the same, trained researcher weighed all participants, with the assistance of a research assistant.

3.6.2.2 Height

Height was determined by means of a *Seca* stadiometer calibrated to the nearest 0.1cm. Participants stood maintaining a fully erect position, without shoes, heels together and back as straight as possible; the heels, buttocks, shoulders, and head touching the vertical surface of the measuring device; the hands hanging freely by the sides, with the palms facing the thighs. The head was positioned in such a way that the angle of the eye and the opening of the external auditory meatus were on a horizontal line. The height measurement was defined as the distance from the floor to the top of the head (Gibson, 2005: 247; Lee and Nieman, 2007:171).

3.6.2.3 HC

HC was measured with the participants standing with arms hanging by the sides at the widest portion of the buttocks, at a level parallel to the floor, accurate to the nearest five mm. A non-stretch measuring tape that fitted snugly was used (WHO, 2008: Online).

3.6.2.4 WC

WC was measured with the participants standing with arms hanging by the sides and the measurement was taken to the nearest five mm midway between the top of the superior iliac crest and the lowest rib in the mid axillary line at a level parallel to the floor, at the end of several consecutive natural breaths. A non-stretch measuring tape that fitted snuggly, was used (WHO, 2008: Online).

3.6.3 Dietary intake

The intake was assessed with questions based on the USDA FGP and participants were asked how many portions they usually eat from each of the six food groups. The standard portion sizes for each food type were listed under each food group. In order to increase the reliability of the self-reported intakes, these portion sizes were given in household measures such as cups and teaspoons, and also, where possible, compared to the sizes of household items.

Questions were also included regarding daily meal frequency.

3.6.4 Lifestyle factors

The information of the physical activity was obtained by the self-administered standard IPAQ Short Form with activities adapted for the study population. The IPAQ questionnaire measures activities by asking the respondent to recall usual participation in activities or in sedentary behaviours over a set period of time. The level of physical activity needed to obtain a health benefit does not have to be strenuous. The IPAQ is a validated tool, used in many studies (Cherin *et al.*, 2012:402).

Questions were included to assess television watching behaviour, smoking habits and alcohol consumption.

3.6.5 Socio-behavioural factors

The socio-behavioural information regarding television watching, sleeping patterns, sun light exposure, participation in hobbies, and religious service attendance were obtained by questions formulated to reflect the association of these parameters with weight management as stated in the literature. Social functioning, emotional health, depression and addictive eating behaviour were assessed by means of published scales developed for questionnaire use.

3.7 Validity

Validity refers to the extent to which a measure actually measures what it is meant to measure (Burns and Grove, 2001: 226). Content validity, in this study, was ensured by including only questions directly related to the aim of the study, based on an in-depth literature study. Data for dietary intakes, television watching, participation in hobbies, religious service attendance and sun light exposure, were compared to published recommendations or were assessed by published scales (physical activity levels, social functioning, emotional eating, depression and addictive eating behaviour). Translation between the English and Afrikaans questionnaires was kept as directly as possible as not to lose the content validity of questions.

3.8 Reliability

Reliability refers to the degree of similarity of the information obtained when collecting data; whether the same value was arrived at every time the measurement was taken; or whether the values varied much on repeated administration (Walsh & Joubert, 2007:24). Reliability, in this study, were improved by the researcher being on hand to explain in the participant's language of choice (Afrikaans or English), any questions on the self-reported questionnaire which may have been unclear; by ensuring through testing in a pilot study, that the questions were not ambiguous and were easy to understand; and by reassuring the participants of confidentiality. To

improve the reliability of the dietary consumption data, examples of portion sizes were given using every day measures and images that were familiar to the participants. The fieldworkers were also trained by the researcher before the data collection in order to improve reliability.

3.9 Foreseen limitations

As the self-administered questionnaire was self-reported there was a chance that the information given by the participants might not have been totally true or accurate. Some of the questions in the questionnaire were also subjective, i.e. those on physical activity, or were based on sensitive information. To address these barriers, the questionnaire was kept as short as possible; questions were worded in a direct and simple, easy-to-understand language; and participants were ensured of confidentiality within the study (as discussed under 'Ethical Considerations').

3.10 Pilot study

A pilot study is a small scale preliminary study conducted before the main research in order to check the feasibility, or to improve the design, of the research. It is frequently carried out before large-scale quantitative research in an attempt to avoid time and money being wasted on an inadequately designed project (Haralambos & Holbourne, 2003: Online).

The pilot study was conducted on 3 May 2013 to ensure that the questionnaires were easily understood, that the data obtained was in line with what the researcher wanted to assess; to ensure that all the relevant food items in the FFQ were included; and to determine how long it would take to complete the questionnaire. The pilot study was done on five randomly selected white women of the Lejweleputswa district. Some changes were made to questionnaires and therefore the information obtained on the women selected for the pilot study wasn't used in the final analysis of the study.

3.11 Study procedure

The study was conducted in the following steps:

STEP 1: Approval was obtained from the Ethics Committee, and permission was form the organiser of the market at NAMPO and the chair person of the Free State Women's Agricultural Union;

STEP 2: The pilot study was conducted;

STEP 3: The questionnaire was adapted, based on the feedback from the pilot study;

STEP 4: Data was collected at NAMPO and the three Free State Women's Agricultural Union meetings;

STEP 5: The statistical analysis was performed with the help of the Department of Biostatistics, Faculty of Health Science; and

STEP 6: The results presented and a dissertation written.

3.12 Statistical analysis

Descriptive statistics, namely means and standard deviations or medians and percentages for continuous data, were computed. The analysis was performed by the Department of Biostatistics at the University of the Free State.

CHAPTER 4:

RESULTS

4.1 Introduction

In this chapter, results on socio-demographic information, anthropometrical measurements, dietary intake, lifestyle factors and socio-behavioural factors, are reported.

4.2 Limitations experienced during the study

The total study population of white females residing in the Lejweleputswa district was estimated to be around 8000, of which 142 women were included into the study, with informed consent. The number of participants was fewer than anticipated during the planning phase, mainly because the questionnaire took time to complete, making it quite difficult to recruit the women in the chosen research setting. Nevertheless, the results are useful to describe risk factors associated with overweight/obesity which have not been previously investigated in rural white women from the Lejweleputswa district.

4.3 Socio-demographic characteristics

The socio-demographical characteristics of the study population are summarised in Table 4.1. Among the sample of 142 white female participants, slightly more lived in rural towns (57.8%) than on farms (42.3%), and most were married (80.3%). More than 40% had a tertiary education; almost half were exclusively housewives (45.1%), almost a fifth was employed, and another quarter self-employed. The median age of the study population was 50 years (22.6 – 82.8 years).

Table 4.1: Socio-demographical results (N=142)

Variable	N	%
Residence		
Town	82	57.8
Farm	60	42.3
Marital status		

Single	10	7.0
Cohabitating	2	1.4
Married	114	80.3
Divorced/Separated	7	4.9
Widowed	9	6.3
Occupation		
Employed	25	17.6
Self-employed	37	26.1
Housewife	64	45.1
Other	16	11.3
Level of education		
High school	70	49.3
Technical college	13	9.2
Technicon/University	56	39.4
Other	3	2.1

4.4 Anthropometry

BMI, BAI, WC, WHR and WHtR were assessed in the study population as measures of adiposity. These results are summarised in Table 4.2.

The median height of the study population was 165 cm (151 – 181 cm), and the median weight was 74.5 cm (51.6 – 145.7kg). The median BMI for the study population was 27.5 kg/m² (18.4 – 54.5kg/m²), which indicates overweight. Based on BMI, 66.9% of the study population were overweight/obese, and just 32.4% had a normal weight for height.

The median BAI was 33.0% (21.6 – 59.3%), which indicates overweight. Overall, 97.2% of the study population could be classified as having excessive levels of body fat.

The median WC was 89.8 cm (62.6 – 177.0 cm), which indicate a substantially increased risk of metabolic complications. Based on WC, 82.5% of the women were classified to be at risk of NCDs associated with abdominal fat deposition: 24.7% had increased risk and 57.8% had substantially increased risk for developing metabolic complications.

The median WHR was 0.82 (0.65 – 1.32), which is above the cut-off point for increased health risk. Based on WHR, 59.9% of the women were classified as at increased health risk.

Median WHtR is ___ (0.39 – 1.01)

Table 4. 2: Anthropometrical results (N=142)

Variable	Category	n	%
BMI			
Underweight	< 18.5kg/m²	1	0.7
Normal weight	18.5-24.9kg/m²	46	32.4

Overweight/obese	> 25kg/m²	95	66.9
BAI			
Average	21 – 25%	4	2.8
Above average	26 – 29%	24	16.9
Overweight	30 – 35%	53	37.3
Obese	> 36%	61	43.0
WC			
No risk	< 80cm	25	17.6
Increased risk	≥ 80cm	35	24.7
Substantially increased risk	≥ 88cm	82	57.8
WHR			
Normal	< 0.8	57	40.1
Increased risk	≥ 0.8	85	59.9
WHtR			
Normal	<0.5		
Increased risk	≥0.5		

4.5 Dietary intake

The diet of the study population was assessed with regard to daily meal frequencies and intakes from the various food groups

4.5.1 Daily meal frequency

Daily meal frequency is summarised in Table 4.3. Most women (91.6%) reported eating supper, while 21.1% usually skipped lunch and 18.3% skipped breakfast Overall, ____% ate only meals and no in-between snacks, while __% ate three meals and three snacks per day. Among those that did snack, 45.1% ate a morning snack, 43.0% an afternoon snack, and 17.0% a late night snack. The data is summarized in Table 4.3:

Table 4.3: Daily meal frequency results (N=142)

Variable	n	%
Breakfast		
Did not eat breakfast	26	18.3
Ate breakfast	116	81.7
Morning snack		
Did not eat morning snack	78	55.0
Ate morning snack	64	45.1
Lunch		
Did not eat lunch	30	21.1
Ate lunch	112	78.9
Afternoon snack		
Did not eat afternoon snack	81	57.0
Ate afternoon snack	61	43.0
Supper		
Did not eat supper	12	8.5
Ate supper	130	91.6
Late night snack		
Did not eat late night snack	118	83.1
Ate late night snack	24	17.0

4.5.2 Daily intake of food groups compared to the recommendations of the USDA FGP

Compared with the recommendations for healthy eating as depicted in the USDA FGP, the majority of the participants (Table 4.3) did not meet the minimum daily requirements for……………………………….

Most (%) had higher than recommended daily intakes of …………

Table 4.4: Daily intake from the basic food groups compared to the recommendations of the UDSA FGP

Intake	Recommendations	n	%
Grains (n=142)			
Below recommendations	< 6 portions/day	135	95.1
Within recommendations	6 – 11 portions/day	7	4.9
Above recommendations	> 11 portions/day	0	0.0
Vegetables (n=142)			
Below recommendations	< 3 portions/day	117	82.4
Within recommendations	3 – 5 portions/day	25	17.6
Above recommendations	> 5 portions/day	0	0.0
Fruit (n=142)			
Below recommendations	< 2 portions/day	72	50.7
Within recommendations	2 – 4 portions/day	69	48.6
Above recommendations	> 4 portions/day	1	0.7
Dairy (n=141)			
Below recommendations	< 2 portions/day	62	44.0
Within recommendations	2 – 3 portions/day	67	47.5
Above recommendations	> 3 portions/day	12	8.5
Meat, poultry, fish, legumes and nuts (n=98)			
Below recommendations	< 2 portions/day	34	34.7
Within recommendations	2 – 3 portions/day	61	62.2
Above recommendations	> 3 portions/day	3	3.1

Table 4.5 Daily intakes of other food types compared to the recommendations

Variable	Category	n	%
Green vegetables (n=142)			
Below recommendations	< 1 portion/day	54	38.0
Within recommendations	≥ 1 portion/day	88	62.0
Orange vegetables (n=142)			
Below recommendations	< 1 portion/day	66	46.5
Within recommendations	≥ 1 portion/day	76	53.5
Meat (n=141)			
	< 1 portion/day	1	0.7
	1 portion/day	96	68.1
	> 1 portion/day	44	31.2
Fish (n=140)			
Below recommendations	< 2 portions/week	140	100
Within recommendations	≥ 2 portions/week	0	0.0
Eggs (n=134)			
	< 1 egg/day	118	88.1
	1 egg/day	16	11.9
Legumes (142)			
	< once/week	57	40.1
	At least weekly	85	59.9
Peanut butter (n=142)			
	Don't eat p. butter	70	49.3
	Eat p. butter	72	50.7
Fats (n=142)			
Below recommendations	≤ 5 portions/day	137	96.5
Within recommendations	6 – 7 portions/day	4	2.8
Above recommendations	≥ 8 portions/day	1	0.7
Sugar (n=140)			

Within recommendations	< 6 portions/day	126	90.0
Above recommendations	≥ 6 portions/day	14	10.0
Chocolate (n=142)			
	< 100g/week	53	37.3
	100g/week	59	41.6
	> 100g/week	30	21.1
Regular soft drinks (n=142)			
2L	Don't drink	128	90.1
	Drink 2L/week	14	9.9
500ml	Don't drink	136	95.8
	Drink 500ml/week	6	4.2
330ml	Don't drink	132	93.0
	Drink 330ml/week	10	7.0
250ml	Don't drink	113	79.6
	Drink 250ml/week	29	20.4
Sugar free soft drinks (n=142)			
2L	Don't drink	125	88.0
	Drink 2L/week	17	12.0
500ml	Don't drink	136	95.8
	Drink 500ml/week	6	4.2
330ml	Don't drink	135	95.0
	Drink 330ml/week	7	5.0
250ml	Don't drink	116	81.7
	Drink 250ml/week	26	18.3
Sports/energy drinks (n=142)			
2L	Don't drink	141	99.3
	Drink 2L/week	1	0.7
500ml	Don't drink	136	95.8
	Drink 500ml/week	6	4.2
330ml	Don't drink	138	97.2
	Drink 330ml/week	4	2.8
250ml	Don't drink	137	96.5
	Drink 250ml/week	5	3.5
Take aways/restaurant (n=126)			
	< once a week	57	42.5
	Once a week	59	44.0
	> once a week	10	7.5

4.6 Lifestyle factors

The lifestyle factors are summarised in Tables 4.5 to 4.____.

4.6.1 Physical activity levels

Physical activity refers to all movement made in everyday life including work, recreation, exercise and sporting activities. Although 42.1% of the women reported being active on at least seven days of the week, based on the IPAQ, more than 80%

of the study population was classified as low (43.6%) and moderately (39.3%) physical active. Based on the IPAQ, only 17.1% were classified as vigorously physically active. The physical activity levels of the women are summarised in Table 4.5.

Table 4.6: Physical activity levels results (N=140)

Variable	Category	n	%
PA levels	Low PA	61	43.6
	Moderate PA	55	39.3
	High PA	24	17.1
Active days	Less than 5 days	53	37.9
	At least 5 days	28	20.0
	At least 7 days	59	42.1

4.6.2 TV watching

One in four women (26.1%) reported watching more than 840 min of TV per week, which constitutes high TV watching.

Table 4.7: TV watching results (N=142)

Variable	Category	n	%
High TV watching	>840min/week	37	26.1
Low TV watching	≤840min/week	105	73.9

4.6.3Smoking

One in ten (9.2%) women in the study population smoked.

Table 4.8: Smoking results (N=141)

Variable	Category	n	%
Non-smoker	Never smoked		
Light smoker	1 – 20 cigarettes		
Heavy smoker	>20 cigarettes		
Ex-smoker	Stopped smoking 1 year before the study		

4.6.4 Alcohol consumption

Almost half (52.5%) of the study population drinks alcohol.

Table 4.9: Alcohol consumption results (N=141)

Variable	Category	n	%
Non-drinker	0 units/day		

Sensible drinker	1 unit/day		
Maximum drinker	2-3 units/day		
Other	>3 units/day		
Cocktails	Did not drink cocktails	139	97.9
	Drank cocktails	3	2.1

4.7 Socio-behavioural factors

The socio-behavioural factors are summarised in Table ___

4.7.1 Sleeping patterns

Almost one on four women (23.2%) in the study population was not sleeping at least 6 hours per night.

Table 4.10: Sleeping patterns results (N=142)

Variable	Category	n	%
Inadequate sleep	<6 hours/night	33	23.2
Adequate sleep	≥6 hours/night	109	76.8

4.7.2 Sun light exposure

Overall, 77.5% of the study population was classified as getting excessive sun light exposure (i.e. > 10 – 15 minutes of direct sunlight per week). Only 3.5% were not getting adequate sun exposure by this definition.

Table 4.11: Sun light exposure results (N=142)

Variable	Category	n	%
Excessive exposure	>10-15 min/week	110	77.5
Adequate exposure	5 min, 2/3xweek	27	19.0
Inadequate exposure	<10 min/week	5	3.5

4.7.3 Participation in hobbies

More than three in four women (77.5%) had a hobby of some sort. Of these women, half (50.0%) engaged in that hobby more than (or equal to) three days per week. One in four (24.8%) of these women admitted to snacking while they were engaged in their hobbies.

Table 4.12: Participation in hobbies results

Variable	Category	N	%

Do you have a hobby? (n=142)	Had no hobby	32	22.5
	Had a hobby	110	77.5
How many days? (n=119*)	<3 days/week	56	48.7
	≥3 days/week	59	51.3
How many hours? (n=119*)	<2 hours/time	47	40.9
	≥2 hours/time	68	59.1
Do you eat while hobby? (n=119*)	Did not eat	86	74.8
	Ate	29	25.2

***the following questions were only asked for those respondents who had a hobby**

4.7.4 Religious service attendance

Most of the study population (82.4%) attended religious services at least once per month. Only about 1 in ten (9.9%) did not attend any religious services.

Table 4.13: Religious service attendance results (N=142)

Variable	Category	n	%
Attendance	No attendance	14	9.9
	<once a month	11	7.8
	≥once a month	117	82.4

4.7.5 Social functioning

Based on the________, _____% were classified as having normal social functioning (__%).

Table 4.14: Social functioning results (N=142)

Variable	Category	n	%
Poor social functioning	SFQ≥10	5	3.5
Normal social functioning	SFQ<10	137	96.5

4.7.6 Emotional eating

Table 4.15: Emotional eating results (N=142)

Variable	n	%

4.7.7 Depression

Based on the PHQ-9 score, most women (59.2%) in the study population suffered from depression from time to time in various degrees.

Table 4.16: Depression results (N=142)

Variable	Category	n	%

Minimal	58	40.9
Mild	60	42.3
Moderate	22	15.5
Moderately severe	2	1.4

4.7.8 Addictive eating behaviour

Based on the YFAS score, the majority (90.1%) of the study population did not exhibit addictive eating behaviour in the form of substance (food) dependence.

Table 4.17: Addictive eating behaviour results (N=142)

Variable	n	%
Not so	132	93.0
Substance taken in larger amount and for longer periods than intended	10	7.1
Not so	11	7.8
Persistent desire or repeated unsuccessful attempts to quit	131	92.3
Not so	127	89.4
Much time/activity to obtain, use, recover	5	10.6
Not so	132	93.0
Important social, occupational, or recreational activities given up or reduced	10	7.0
Not so	95	66.9
Use continues despite knowledge of adverse consequences	47	33.1
Not so	94	66.2
Tolerance (marked increase in amount; marked decrease in effect	48	33.8
Not so	123	86.6
Characteristic withdrawal symptoms; substance taken to relieve withdrawal	19	13.4
Not so	120	84.5
Use causes clinically significant impairment or distress	22	15.5
Not so	128	90.1
Substance dependence	14	9.9

4.8 Associations between variables

Simple statistics and the Pearson correlation coefficient were used to determine if any relationships exist between the participants' anthropometrical measurements and the risk factors for overweight/obesity. Tables 4.18 to 4.21 show the results.

Table 4.18: Pearson correlation and correlation coefficient of anthropometrical measurements with age

Variable	With BMI	With BAI	With WC	With WHR	With WHtR
Age (n=142)	r=0.16;p=0.05	r=0.18;p=0.03	r=0.25;p=0.003	r=0.21;p=0.01	r=0.33;p=0.0001

There were weak correlations between all of the anthropometrical measurements and age, meaning that with age your weight, fat percentage and/or waist circumference can increase.

Table 4.19: Pearson correlation and correlation coefficient of anthropometrical measurements with dietary intake

Variable	With BMI	With BAI	With WC	With WHR	With WHtR
Meat (n=141)	-	-	r=-0.13;p=0.12	r=-0.18;p=0.03	r=-0.14;p=0.10
Fish (n=140)	-	-	-	r=0.11;p=0.20	-
Peanut butter (n=139)	r=0.13;p=0.12	r=0.15;p=0.07	r=0.24;p=0.005	r=0.20;p=0.02	r=0.21;p=0.01
Dairy (n=141)	-	r=-0.11;p=0.19	-	-	-
Sugar (n=140)	-	r=-0.16;p=0.06	r=-0.11;p=0.19	-	r=-0.13;p=0.13
Sugar free soft drinks (n=142)	r=0.16;p=0.06	-	-	-	-

With regards to dietary intake, there are some weak correlations between specific foods eaten and anthropometrical measurements. The results showed that eating meat had an inverse relationship with WC, WHR, and WHtR; meaning that people who ate more meat, had slightly lower WC, WHR, and WHtR.

Eating fish had a weak correlation with WHR.

Eating peanut butter had weak correlations with all of the anthropometrical measurements; showing that the more peanut butter eaten, the bigger the anthropometrical measurements.

Eating dairy products showed a weak inverse correlation with BAI, but not with the other measurements.

Eating sugar had weak inverse correlations with BAI, WC, and WHtR, meaning that those anthropometrical measurements were smaller when sugar intake was slightly higher.

Drinking sugar free soft drinks had a weak correlation with BMI; meaning that the more sugar free soft drinks a person have, the bigger the BMI.

Table 4.20: Pearson correlation and correlation coefficient of anthropometrical measurements with physical activity and TV watching

Variable	With BMI	With BAI	With WC	With WHR	With WHtR
Physical activity	-	-	-	r=-0.12;p=0.17	r=-0.25;p=0.003
Vig_total_minutes/week	r=-0.23;p=0.006	r=-0.23;p=0.007	r=-0.23;p=0.007	-	-
Mod_total_minutes/week	-	r=-0.13;p=0.1	-	-	-
Walk-total-minutes/week	r=-0.10;p=0.22	r=-0.14;p=0.09	-	-	-
Total activity minutes	r=-0.20;p=0.02	r=-0.24;p=0.004	r=-0.19;p=0.02	-	r=-0.21;p=0.01
Sit total minutes	r=0.18;p=0.03	r=0.14;p=0.08	r=0.22;p=0.008	r=0.19;p=0.03	r=0.19;p=0.02
MET min/week across all Vigorous activity domians	r=-0.27;p=0.001	r=-0.28;p=0.007	r=-0.25;p=0.003	r=-0.10;p=0.24	r=-0.27;p=0.001
MET min/week for all activity domains	r=-0.19;p=0.02	r=-0.25;p=0.004	r=-0.22;p=0.009	-	r=-0.22;p=0.008
kCal/week for walking across all domains	r=0.14;p=0.1	-	-	-	-
kCal/week for moderate activities	r=0.16;p=0.05	-	-	-	-
kCal/week for vigorous activities	r=-0.22;p=0.01	r=-0.23;p=0.006	r=-0.21;p=0.01	-	r=-0.24;p=0.004

Physical activity had weak correlations with all of the anthropometrical measurements. It was shown that the more a person sits, the bigger the anthropometrical measurements; and the more a person were physically active, the smaller the anthropometrical measurements.

Table 4.21: Pearson correlation and correlation coefficient of anthropometrical measurements with socio-behavioural factors

Variable	With BMI	With BAI	With WC	With WHR	With WHtR
Emotional eating	**r=0.33;p=0.0001**	**r=0.31;p=0.0002**	**r=0.31;p=0.0001**	r=0.16;p=0.06	r=0.28;p=0.0009
Depression	r=0.14;p=0.11	-	-	-	-
Addictive eating behaviour					
Overuse (n=142)	r=0.25;p=0.003	r=0.19;p=0.02	r=0.26;p=0.002	r=0.17;p=0.005	r=0.24;p=0.004
Persistent desire (n=142)	r=0.19;p=0.02	r=0.17;p=0.05	r=0.14;p=0.10	-	r=0.13;p=0.10
Reduced social (n=142)	r=0.21;p=0.01	r=0.16;p=0.05	**r=0.31;p=0.0002**	r=0.29;p=0.0006	r=0.29;p=0.0005
Ignore hazard (n=142)	r=0.25;p=0.003	r=0.20;p=0.02	r=0.19;p=0.03	-	r=0.16;p=0.06
Tolerance (n=142)	r=0.23;p=0.006	r=0.22;p=0.009	r=0.18;p=0.03	-	r=0.14;p=0.10
Withdrawal (n=142)	r=0.12;p=0.10	-	r=0.18;p=0.04	r=0.18;p=0.03	r=0.16;p=0.06
Symptoms (n=142)	**r=0.30;p=0.0004**	r=0.24;p=0.005	r=0.29;p=0.0005	r=0.17;p=0.04	r=0.25;p=0.003

Emotional eating had a moderate (0.3 – 0.5) correlation with BMI (r=0.33;p=0.0001), BAI (r=0.31;p=0.0002), and WC (r=0.31;p=0.0001). The higher the respondent's score for emotional eating, the higher the BMI, BAI, and WC was. These were all three statistically significant.

Depressive symptoms had a weak correlation with BMI.

With regards to addictive eating behaviour, there were two correlations that were also statistically significant. These were "important social, occupational, or recreational activities given up or reduced" with WC (r=0.31;p=0.0002); and "use cause clinically significant impairment or distress" with BMI (r=0.30;p=0.0004). There were various more weak correlations between addictive eating behaviour and anthropometry (see Table 4.21).

4.9 Summary

Chapter 5:

The results of the study are interpreted and discussed in the context of the current body of evidence on the subject of overweight/obesity among white women in South Africa.

Chapter 6:

The conclusions from the study are set out in this chapter. Recommendations regarding the prevention of overweight/obesity among white women from the Lejweleputswa district; and recommendations for further research, are discussed.

Although it can be prevented, overweight/obesity is globally a big problem. The aetiology is multi-factorial. Despite all the contributing factors such as genetics, metabolic, environmental, and socio-behavioural, the core of overweight/obesity development is an energy imbalance, with energy intake exceeding energy expenditure. Weight loss and maintenance is essential to reduce or prevent the overweight/obesity-related high risk co-morbidities and mortality. The goal of overweight/obesity intervention initially is to lose weight and more importantly maintain the weight loss in the long term. Ideally, the combination of dietary modification, physical activity, and socio-behavioural/lifestyle modification are essential components of any overweight/obesity programme. Sometimes being overweight/obese is not the real problem, but the symptom of another problem. By asking a client questions about not only nutritional and physical activity factors, but also of relevant socio-behavioural factors, underlying problems could be detected, and addressed. Pharmacotherapy and surgery are possible co-interventions, but are generally prescribed when more aggressive management is required. The dietician plays an important role in the client's assessment, evaluation, dietary prescription, dietary counselling, monitoring and follow-up. However, overweight/obesity cannot be managed solely at the individual's level. In order to solve the problem of overweight/obesity, the environment must be changed to facilitate and sustain the necessary changes made.

Emotional health for the purpose of this study will refer to factors included in the "Three-Factor Eating Questionnaire (TFEQ)", which is a self-assessment scale widely used in studies of eating behaviour in overweight and normal weight individuals (Cappelleri *et al*. 2009:611).

The TFEQ-R21 consists of 21 questions on a 4-point response scale (definitely true/mostly true/mostly false/definitely false). Responses to each of the 21 questions are given a score between 1 and 4 and question scores are summated into scale scores for cognitive restraint, uncontrolled eating, and emotional eating (Cappelleri *et al*. 2009:613).

As this study is only concerned with emotional eating, only those 6 questions will be used in the questionnaire (Appendix 1).

Before calculating the emotional eating domain's score, the questions must be reverse coded.

Conclusion

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