CHAPTER 7

OBESITY
IN SOUTH AFRICA

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1. INTRODUCTION

Obesity can be described as an imbalance between energy intake and expenditure such that excess energy is stored in fat cells, which enlarge or increase in number. However, this complex medical condition is affected by a host of contributing factors that will be discussed in the context of the South African situation. Obesity is defined as a body mass index (BMI) of >30 kg/m^2, according to WHO criteria.[1]

Obesity has become a global epidemic with an estimated 1.3 billion people overweight or obese.[2] Its prevalence in developed countries, such as the United States, is as high as 26.6% in men and 32.2% in women above age 20 years.[3] However, obesity is not only a problem of developed nations but is becoming an increasing problem in countries undergoing epidemiological transition, such as South Africa, Mexico and South American countries.[4-6] In South Africa, where under-nutrition, poverty, and infectious diseases, such as HIV/AIDS and tuberculosis, are realities, the problem of obesity could be viewed as less pressing. However, obesity and its co-morbidities negatively affect the lives of many South Africans and the consequent burden of disease contributes to the increasing cost of health care, both at a state level and in the private sector.[7]

2. EPIDEMIOLOGY OF OVERWEIGHT AND OBESITY IN SOUTH AFRICA

The overall prevalence of overweight (BMI >25) and obesity (BMI >30) in South Africa is high, with more than 29% of men and 56% of women being classified as overweight or obese.[4] This is higher than that reported in other African countries (Table 7.1), particularly in women, since nearly 30% of South African women aged between 30 and 59 years are obese. The first South African Demographic and Health Survey (SADHS), undertaken in 1998 and published in 2002,[4] included a sample of 13 089 South Africans aged 15-95 years old. Results highlight the influence of age, gender and demographics, as well as ethnicity and socio-economic status on the prevalence of obesity (Table 7.2).

In a sample of 7 726 South African women aged 15-95 years old, black women had the highest prevalence of overweight and obesity (58.5%), followed by women of mixed ancestry (52%), white women (49.2%) and then Indian women (48.9%). Urban women were found to have a significantly higher BMI than their rural counterparts, and in both groups, BMI was found to increase with age. Central obesity (defined by cut-off points for waist:hip ratio of 1.0 and 0.85 for men and women, respectively) was found in 42.2% of women and was most prevalent in urban African and women of mixed ancestry.[4]

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Table 7.1. Mean BMI of African countries categorised by age and gender, adapted from International Obesity Task Force: Global Burden of Disease Analyses 2002

Country	Sex	Age in Years						
		5-14	15-29	30-44	45-59	60-69	70-79	80+
Cameroon	M		23.7	24.4	24			
	F		24.6	24.8	25			
Ethiopia	M	14.2	17.5	18.3	18	18	17.9	19.8
	F	14.5	18.9	18.6	17.3	16.7	17.6	18.6
Gambia	M		19.6	20.5	20.9	21	20	
	F		21	21.9	21.8	21.3	20.9	
Ghana	M							
	F		21.8	22.4	21.4			
Kenya	M							
	F		21.7	22.3	22			
Malawi	M				19.8	19.8	19.7	
	F				20.5	20.5	19.6	
Mali	M		18.9	20.5	20.8	20.3	19.6	20.2
	F		19.9	21.1	20.6	20	19.5	20.8
Nigeria	M		19.8	20.9	21.5			
	F		21	21.8	20.3			
Senegal	M		18.2	19.9	21	20.7	19.8	19.2
	F		19.6	21.4	22.1	22.2	21.3	20.7
Seychelles	M		22.9	23.5	23.1	23.2		
	F		23.2	25.7	27.2	27.5		
South Africa	M	13.8	21.5	24.2	25.3	24.8	24.4	
	F	14	24.4	28.5	29.9	28.8	27.7	
Tanzania	M							
	F		21.8	22.3	21.6			
Zimbabwe	M	15.3	19.5	20.8	21	21	20.1	20
	F	15.4	21.3	23	23.5	21.8	20.5	20.3

A different pattern was seen in men. In a sample of 5 401 South African men aged 15-95 years, the prevalence of overweight and obesity was highest in white men (54.5%), followed by Indian men (32.7%) and men of mixed ancestry (31%), with the lowest prevalence in African men (25%). Older men and those living in urban areas had significantly higher BMIs than younger men and men living in rural areas. Central obesity was found in 9.2% of men with higher levels in older and white men.[4]

Furthermore, a major public health concern is that obesity and overweight are not limited to the adult South African population but have also been well documented in adolescents and young people. For example, 10% of South African women surveyed in the SADHS, aged between 15-24 years, were already considered obese.[4] In addition, the Youth Risk Behaviour Survey (n=9 054), conducted in 2002, found that over 17% of adolescents were overweight, and 4.2% were obese.[8] In a regional school-based health and fitness survey of nearly 5 000 children aged 12-18 years, it was estimated that the future prevalence of obesity in black girls at the age of 18 to be 37%, compared to 10% and 20% for white girls and girls of mixed ancestry, respectively (EV Lambert, unpublished data). Overall, current South African research suggests a significant problem of over-nutrition in adults and young women, and that urban black women are at greatest risk.

It is difficult to quantify the increase in prevalence of obesity in South Africa as, prior to the SADHS, only regional, cross-sectional studies were conducted, therefore. However, an increase in the prevalence of obesity has been reported in other developing nations undergoing epidemiological transition[6,9,10] For example, in the developing Mexican states, the prevalence of obesity in adult women increased from 9.4% in 1988 to 24.4% in 1999.[6] In Brazil, a tripling in the prevalence of overweight from 4.1% in 1974 (n=56 295) to 13.9% in 1997 (n=4 875) was reported in a sample group including both genders and all ages.

Table 7.2. The anthropometric pattern of adults (> 15 years) from the national DHS in South African population groups, adapted from Puoane *et al*.[4]

	Men %					Women %				
	African (n=4006)	Mixed (n=740)	Indian (n=174)	White (n=470)	Total (n=5390)	African (n=5897)	Mixed (n=986)	Indian (n=262)	White (n=572)	Total (n=7717)
Underweight BMI < 18.5	12.9	12.1	16.9	5.0	12.2	4.8	10.5	14.9	3.1	5.6
Normal weight BMI 18.5-24.9	61.7	57.1	50.3	40.4	58.6	36.7	37.3	36.1	47.8	37.8
Overweight BMI 25-30	19.4	23.1	24.0	36.3	21.7	26.7	25.9	27.8	26.5	26.6
Obese BMI > 30	6.0	7.7	8.7	18.2	7.5	31.8	26.3	21.1	22.7	30.0

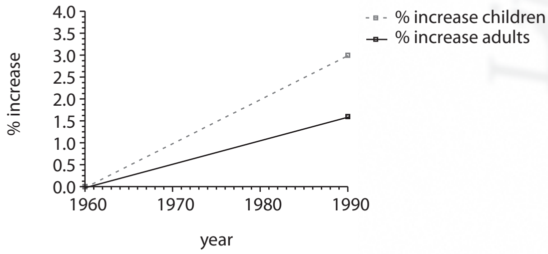

Figure 1: The percentage increase in obesity in children and adults between 1960 and 1990[14]

Similar findings have been reported in Mauritius, where the prevalence of overweight or obesity (BMI >25) increased from 26.1% to 35.7% in men and from 37.9% to 47.7% in women between 1987 and 1992.[11] Such marked increases in the prevalence of obesity may be attributed, at least in part, to rapid changes in dietary intake, urbanisation, changes in physical activity levels and leisure activities.[5,11,12]

Childhood obesity is an increasing problem worldwide with 22 million children under age 5 years being classified as overweight.[13] According to the NHANES III database, the prevalence of overweight (>95th percentile) in American children has tripled between the 1960s and the 1990s, in contrast to a 1.6-fold increase in adults over the same period (Fig. 1).[14,15] The increase in obesity is greatest in developing countries, as, for example, in Chile the prevalence of obesity in first graders increased from 6.5% and 7.8% in boys and girls, respectively in 1987 to 17% and 18.6% in 2000.[16]

Similarly, childhood obesity and overweight are becoming increasingly evident in South Africa. The National Household Food Consumption Survey reported that 17.1% of South African children between the ages of one and nine living in urban areas are overweight.[17] Moreover, the THUSA BANA study on 10-15-year-old children from five different regions in the North-West province found the BMI and percentage body fat of black children (17.4, 19.9%, respectively) and mixed origin (16.8, 17.6%) to be lower than those of white (19.0, 20.8%) and Indian children (17.5, 20.2%).[18] Body fat was significantly higher in girls of all races (23%) than in boys (15.2%). Results from this study suggest that ethnicity and gender affect BMI and body fat percent in South African children. In contrast, Monyeki *et al*.[19] found that the prevalence of obesity and overweight in rural children aged 3-10 years from Limpopo province was low (0-2.5% and 0-4.3% in boys and girls, respectively). Therefore, urbanisation also appears to influence the prevalence of obesity in South African children.

3. MORBIDITY SEQUELAE

Obesity can be classified as a chronic disease, similar to hypertension or insulin resistance. There are a large number of clinical problems associated with being obese. These can be categorised into those that are associated with excess adipose tissue and those that are associated with the metabolic effects of the increased adiposity.[20] Those diseases associated with increased fat mass include osteoarthritis, sleep apnoea and psychological problems, whereas the diseases associated with the metabolic effects of adiposity include coronary heart disease (CHD),[21,22] hypertension,[23] type 2 diabetes mellitus[24-26] and certain types of cancer.[22,27,28] The metabolic effects of excess adipose tissue are exerted via increased release of free fatty acids (FFA) and the production of adipose-derived factors known as adipokines, that have specific functions, all of which are not yet fully understood. These products include hormones (leptin and adiponectin), cytokines (TNF-α, IL-6), transcription factors (PPARγ) and other adipokines (angiotensinogen, resistin). Additionally, enzymes integrally involved in the local production of cortisol (11β-hydroxysteroid dehydrogenase type-1) and oestrogen (aromatase) are also produced in adipocytes.[29]

However, the distribution of the adipose tissue influences its metabolism and thereby disease risk, independently of the effects of the size of the adipose tissue stores. Accumulation of fat in the abdominal area, particularly in the visceral fat compartment, is associated with increased risk of insulin resistance, diabetes, hypertension, dyslipidaemias and atherosclerosis.[30] Visceral adiposity is also the cornerstone of the metabolic syndrome, which is characterised by a clustering of cardiovascular risk factors, including insulin resistance and glucose intolerance, dyslipidaemia, hypertension and a prothrombotic and pro-inflammatory state.[31] Strong support for a causative role of visceral fat in the metabolic syndrome comes from studies in which surgical removal of visceral fat is associated with improved insulin sensitivity and delayed onset of diabetes.[32]

The physical and biological properties of visceral and subcutaneous adipose tissue are therefore different. Visceral adiposites are smaller than subcutaneous cells,[33] but are more lipolytically active because of increased density of β-adrenergic receptors.[34] In addition, the production of adiposity-derived proteins between adiposity depots is different. A recent study undertaken at University of Cape Town (UCT), found that the gene expression of leptin, adiponectin and hormone sensitive lipase were higher in subcutaneous adipose tissue depots compared to visceral adipose tissue depots (Goedecke JH, unpublished data). In contrast, angiotensinogen, TNF and IL-6 mRNA levels, as well as 11β-hydroxysteroid dehydroganse-type 1 enzyme, were greater in visceral compared to subcutaneous adipose tissue depots. These findings are supported by international studies.[29,35]

The disparate disease risk associated with the different adipose tissue depots has important implications for South Africa, a country of diverse ethnic origin. Differences in regional fat distribution have previously been reported in American women, with African-American women presenting with less visceral fat than do Caucasian women.[36-38] Similarly, a series of studies undertaken at the University of the Witwatersrand, comparing groups of 8 to 15 obese black and white women, demonstrated that black women had significantly less visceral adipose tissue than white women (~72 mm vs. 140 mm),[39,40] who were assessed using computerised tomography (CT), when matched for BMI.[41-43] However, despite having less visceral fat, the obese black women were more insulin resistant and described as having relative insulinopaenia compared to the white women.[41-44] In addition, *in vitro* and *in vivo* studies found greater adipose tissue lipolysis and a greater degree of adipose tissue insulin resistance in obese black compared to the obese white women.[42,44] These findings are similar to those in African-America women. Lovejoy *et al*.[45] found that African-American women were more insulin resistant than were Caucasian women, despite having less visceral adipose tissue. However, the insulin resistance in these women was associated with hyperinsulinaemia.[36]

Recent studies by Punyadeera *et al*.[46] did not find ethnic differences in insulin sensitivity or secretion, as assessed by standard oral glucose tolerance tests, though differences in visceral adipose tissue are described.[39,47] Furthermore, blood lipid levels remain different between the obese black and white women, with higher total cholesterol, low-density lipoprotein cholesterol (LDLC) and triglyceride concentrations in white women consistent with higher levels of visceral fat.[43,46]

In contrast to these findings, two recent studies undertaken in South African women found no ethnic differences in body fat distribution between black, white or mixed ancestry women of varying body fatness (Goedecke JH, unpublished data). Interestingly, these studies also explored ethnic differences in the deep and superficial subcutaneous adipose tissue compartments (separated at the level of the *fascia superficialis*), and, similar to recent international research findings, showed that the deep subcutaneous adipose tissue compartment showed as strong a relationship with insulin resistance as visceral adipose tissue.[48,49] However, no differences in deep or superficial adipose tissue area or volume were found between the ethnic groups. The main finding of these studies was that when women of different ethnic origin were matched for total and visceral adiposity, no differences in insulin sensitivity or their lipid profile were reported (Goedecke JH, unpublished data). Accordingly, no ethnic differences were found in the gene expression of adiposity-derived proteins shown to be associated with obesity and insulin resistance, including leptin, adiponectin, PPARγ, angiotensinogen, resistin, as well as cytokines (TNF-α, IL-6, IL-1) or those products involved in local glucocorticoid metabolism (11β-hydroxysteroid dehydrogenase type-1, glucocorticoid receptor-α) (Goedecke JH, unpublished data).

Studies including a larger, more representative sample of South Africans are required to characterise ethnic differences in body fat distribution accurately to understand the nature of the association between body fat distribution and morbidity sequelae. In contrast to the small studies undertaken, results from the SADHS, which included over 7 000 South African women, found that black women and those of mixed ancestry had greater waist circumference and waist:hip ratios, as a proxy for central adiposity, than white or Indian women. In fact, more than twice as many black women as white women had a waist:hip ratio greater than 0.85 (35.3% vs. 17.4%, respectively).[4] Moreover, studies undertaken in the USA have found that the relationship between body fat distribution and risk factors for disease are different between African Americans and Caucasians.[36]

3.1 Type 2 diabetes

Obesity and type 2 diabetes are closely associated in men and women of all ethnic groups.[50,51] The risk of type 2 diabetes increases with the extent and duration of overweight and the degree of central adiposity.[20] In the Nurses Health Study, which included 114 281 female nurses, the risk of diabetes increased 40-fold when BMI increased from ≤22 to 35.[50] A similar relationship was observed in the Health Professionals Follow-Up Study that included a cohort of 51 529 men. In this study, they found that the relative risk of developing diabetes was 42 in men with a BMI of >35 compared to those with a BMI of <23.[51] According to government reviews in the UK, obesity (BMI >30) is associated with a relative risk of 5.2 and 12.7 for type 2 diabetes in men and women, respectively.[3] No large-scale risk assessment study for type 2 diabetes, including BMI as a determinant, has been undertaken in South Africa.

3.2 Coronary heart disease

Obesity is associated with an increased risk of CHD with a relative risk of approximately 2.8 and 3.4 for men and women, respectively.[52] Research on women in the USA found that the risk of developing CHD increased 3.3-fold when BMI was >29.[22] In South Africa, 4.8 million people presented with hypercholesterolaemia, with 3.1 million people having raised LDLC levels.[53] Both of these conditions lead to an increased risk of CHD. Interestingly, although they have a higher prevalence of obesity, black South Africans appear to be less prone to hypercholesterolaemia and raised LDLC levels than people who are white or of mixed ancestry.[53] For example, Seedat *et al*.[54] found that in an urban Zulu population, the prevalence of CHD was only 2.4%. In a study among 976 peri-urban South Africans of mixed ancestry from the town of Mamre, Steyn *et al*.[55] found that hypercholesterolemia was present in 47% of men and 46% of women.

3.3 Hypertension

Obesity is associated with a significantly increased risk of hypertension. According to a recent population-based survey, including 195 005 randomly selected American adults, obesity was associated with a relative adjusted risk of 3.5 for hypertension.[56]

According to the WHO/ISH guidelines for hypertension (140/90 mmHg), after adjusting for age, approximately 21% of the adult South African population are hypertensive.[57] Data from the SADHS showed that urban men of mixed ancestry had a lower risk of developing hypertension than black or white men, while rural African women had a significantly decreased risk of hypertension when compared to white women.[57] However, after sociodemographic variables are taken into account, there are no appreciable differences in the prevalence of hypertension among the population groups of South Africa.

3.4 Cancer

Obesity is associated with an increased risk of certain forms of cancer,[22,27] which have a hormonal basis.[58] Therefore, in women obesity is associated with cancers of the reproductive system, as excess body fat results in excess production of oestrogen by adipose stromal cells.[20] In men, obesity is associated with cancer of the rectum, colon and prostate.[20] Cancer also appears to be influenced by ethnicity, urbanisation and other socio-cultural factors. In 2004, Walker *et al*.[59] found that rural black South Africans had a very low incidence of breast cancer (5-10/100 000), whereas the incidence in urban black women was much higher (15.1/100 000).

3.5 Psychological implications

Overweight and obesity have psychological implications. Being overweight can lead to body image issues, unhappiness and disordered eating,[60-63] as the disorder is stigmatised.[64] Research has shown that overweight during adolescence has important social and economic consequences. In fact, a study reported that adult women who were overweight in adolescence were less likely to be married, had a lower household income and a higher household poverty rate than women who had not been overweight, independent of their baseline socio-economic status and aptitude test scores.[64] Research has also shown that women who do not meet cultural ideals with regard to weight may also be more likely to suppress anger and engage in anger avoidance behaviour.[62] Additionally, results from the Medical Outcomes Study Short-Form Health Survey (SF-36) demonstrated that obese people had abnormalities in health-related quality of life.[65]

3.6 Osteoarthritis

Osteoarthritis is significantly increased in overweight individuals.[20] Felson *et al.*[66] found that in an American population there was an increased risk of osteoarthritis of the knees and ankles in overweight men (relative risk=1.51) and in obese women (2.07). In South Africa, little epidemiological data have been published on this condition, with none related to obesity.[67,68]

3.7 Morbidities in children

Childhood obesity has negative health implications with approximately 60% of overweight 5-10-year-old children presenting with at least one associated cardiovascular risk factor and 25% presenting with two or more risk factors.[69] For example, a tremendous increase in type 2 diabetes in children and adolescents has been documented. In a longitudinal study in the USA, including 1 027 adolescents, it was found that the incidence of type 2 diabetes increased tenfold between 1982 and 1994.[70] Obesity, as well as family history and ethnicity, were found to be important risk factors.[70] In addition, similar to the findings in adults, intra-abdominal adipose tissue in obese children has a significant relationship with adverse health conditions, including dyslipidaemia and glucose intolerance.[71,72]

Childhood obesity also results in the development of co-morbid conditions of obesity in adulthood, since childhood obesity often persists into adulthood.[73-76] In fact, childhood obesity has a greater effect on the development of the metabolic syndrome than becoming obese as an adult.[77,78] A 55-year follow-up study of previously obese adolescents, showed a higher long-term mortality outcome with obesity in men, but not in women.[66] However, women who had been obese as adolescents were eight times more likely to report difficulty with activities of daily living than those who were lean in adolescence.[79] Additionally, obesity in adolescence has a negative impact on socio-cultural and economic factors, such as household income, self-esteem, marital status and education level, particularly in women. This can perhaps be because of weight-based discrimination.[64]

4. UNDERLYING MECHANISMS AND DETERMINANTS

4.1Genetics

Bouchard *et al.*[80,81] have reported that approximately 75% of the variation in percent body fat and total fat mass is determined by culture and lifestyle, whereas 25% can be attributed to genetic factors. Additionally, there is strong evidence for a genetic component to obesity in humans, based on correlational studies of BMI between family members, adoptees and their biological relatives, and between twins.[82,83] However, obesity is a polygenic condition with well over 50 different loci having been linked to it.[84]

Obesity is also a complex phenotype in which the interaction of multiple genes and environmental conditions leads to the manifestation of the condition. Although non-genetic factors are important, it is unlikely that these factors alone can fully explain the prevalence of obesity and associated co-morbidities in South Africa.

4.2 Intra-uterine and early life influences

There is a body of evidence linking an adverse intra-uterine environment to the development of chronic disease later in life. Early work by Barker and colleagues[85-87] in Southampton found an association between low birth weight and cardiovascular disease mortality.

There is now incontrovertible evidence, based on large numbers of epidemiological studies conducted in both developing and developed countries, that small size at birth in full-term pregnancies is linked with the subsequent "programming" of the major features of the metabolic syndrome, i.e. glucose intolerance, increased blood pressure, dyslipidaemia and increased mortality from cardiovascular disease.[85-92] Over the past two decades, this field has progressed, and is now largely theoretically based on the so-called 'foetal origins' (of chronic disease). More recently, there is growing recognition of the importance, not only of intra-uterine programming, but also of subsequent early life influences, interacting with genetic factors, resulting in an adult chronic disease phenotype. However, what is less straightforward is whether foetal programming results in increased risk for the development of obesity. In one of the earlier studies, Ravelli *et al.*[93] described the impact of low birth weight on the subsequent risk for developing obesity in offspring born during the Dutch "Hunger Winter" of 1944-45. Individuals who were exposed to the famine while in utero during the first and second trimesters were nearly three times more likely to be obese as young adults, compared to those who were not exposed, or who were exposed during the third trimester. Two recent reviews have summarised the current evidence concerning the relationship between birth weight and later obesity. Ong and Dunger[94] corroborated the association between low birth weight and risk for increased adiposity in adulthood. Conversely, there are studies in which low birth weight has been associated with increased visceral adipose tissue distribution.[95]

However, in developing countries, the progression to obesity appears to be usually dependent, in part, on the interaction between birth weight and subsequent growth during critical developmental windows.[96] Furthermore, morbidity associated with low birth weight is also dependent on this interaction. This was elegantly demonstrated by, Crowther *et al.*,[90] who found that in 7-8-year-old children participating in the Birth-to-Twenty cohort, weight gain velocity was associated with increased adiposity, measured by skin-fold thickness. In the same cohort, those who had a low birth weight, but who were above the median weight for age when studied, also presented with increased blood pressure at age 5 years,[97] and a greater insulin response to oral glucose tolerance testing at age 7 years.[90] In another South African birth cohort, Levitt *et al.*[98] were unable to demonstrate an association between birth weight and adult obesity or adipose tissue distribution. Perhaps one of the most provocative cases for the role of early life exposures on later obesity may be found in the results of the recent national Household Food Consumption Survey. Nearly 20% of the children were stunted, while 17% were considered overweight. However, stunting was found to confer an increased risk for overweight in children (odds ratio: 1.8; 95% CI: 1.48, 2.20).[17] Furthermore, underweight children have been found in the same households as overweight caregivers.[99]

4.3 Dietary intake

Although excessive calorie intake is responsible for the development of obesity, high-fat diets promote fat accumulation significantly more than high-carbohydrate diets because of the high energy density, metabolic efficiency, palatability, poor regulation and weak satiating effect of fat.[100] This is especially relevant in South Africa where increased urbanisation is associated with the adoption of a more westernised diet, which is higher in fat and has less carbohydrate and fibre than a traditional diet. Bourne *et al.*,[12] in a review of the nutrition transition in the black population in South Africa, describe the trends in dietary intake from the few available studies undertaken in rural and urban areas. Although these diets met the prudent dietary guidelines, there was a general trend for an increase in fat intake and a decrease in carbohydrate intake in rural and urban areas. A comparison of macronutrient intake for adults, aged 15-64 years living in urban areas, showed a 10.9% reduction of carbohydrate intake (69.3% to 61.7%) and a 59.7% increase in fat intake (16.4% to 26.2%) from 1940 to 1990. The changes reported over this period were more dramatic than were those observed in Western countries undergoing rapid industrialisation over longer periods.[12] In contrast, the change in macronutrient intake was not as marked in the rural areas; studies undertaken between 1970 and 1990 observed an increase in fat intake from ~20% to 28% and a decrease in carbohydrate intake from ~70% to 60%. In the North West province, a recent study including 1 040 adult black women from 37 randomly selected sites, found a weak, but significant positive association between BMI and dietary energy and fat intake.[101] They also found that the lowest fat intake was observed in the rural areas (46 g/day), whereas the highest fat intakes were reported in the urban middle-class areas (56 g/day).

Therefore, a high dietary energy and fat intake is likely to be a major contributing factor to the high prevalence of obesity in South African populations, particularly those living in urban areas. However, a high dietary fat intake alone cannot account for the extent of the problem. Weight gain associated with a high fat intake may also be caused, in part, by an inability to increase fat oxidation when fed a high-fat diet.[102,103] Indeed, Chitwood *et al*.[104] found that African American women had lower levels of fat oxidation at rest and during exercise than did their Caucasian counterparts. No studies are available that have examined ethnic differences in nutrient partitioning in South Africa. However, there are currently two studies being undertaken at the University of Cape Town that are characterising ethnic differences in nutrient partitioning in women. The first study is examining dietary intake in relation to resting energy metabolism using indirect calorimetry (EV Lambert, unpublished data), whereas the second study is accurately measuring 24-hr energy expenditure and fuel utilisation in a whole-room calorimeter (L Dugas, unpublished data).

4.4 Physical activity

The role of physical activity in the prevention and management of overweight and obesity is linked, in part, to the impact of physical activity on energy expenditure, body composition, and substrate oxidation and metabolism.[105] Furthermore, regular exercise is associated with increased adherence to dietary intervention for weight loss and weight control, improved self-efficacy and better long-term weight loss maintenance.[105] As such, physical activity has the potential to be a powerful "agent of change" in the prevention and management of overweight and obesity.

Despite the paucity of South African studies in which physical activity or inactivity have been studied in relation to obesity, the few published studies reflect the well-established, protective role of physical activity for the development of obesity and associated co-morbidities. The THUSA study has provided important insights into this relationship, in particular, in South African communities moving from urban to rural areas. In this cross-sectional study of approximately 1 000 persons, physical inactivity was a major determinant of obesity in adult black women of the North West.[101] Subjects in the highest tertile of physical activity were less likely to be obese (odds ratio: 0.38; 95% CI: 0.22, 0.66), and inactivity was the strongest predictor of obesity, when compared to other demographic and self-reported dietary factors.[101] Moreover, associated cardiovascular risk factors were significantly attenuated in those women who were physically active, even at the same level of obesity.[106]

In another survey, conducted in more than 550 economically active South Africans (from 2 100 who were originally contacted), self-reported inactivity was a major risk factor for overweight and obesity, along with lower levels of education, ethnicity and having at least one overweight parent.[107]

The protective effect of physical activity for obesity is not limited to adults, and, in fact, an inverse association between activity levels and fat mass, measured by television viewing time, has been reported in South African children.[108] In a regional, cross-sectional survey of children's health and fitness status of 12-18-year-old children in 14 schools in the Western Cape (boys n=2 026, girls n=2 792), current levels of obesity were associated with inactivity as measured by television time, lower fitness levels and a low reported daily intake of fruit and vegetables. Moreover, television viewing time was greater, and opportunities for school-based or after-school sports and physical activity were fewer, in persons of lower socio-economic status.[109]

4.5 Socio-cultural factors

In South Africa, there is large cultural diversity that influences perceptions of body image. However, as a whole, South African men and women have inaccurate perceptions of their body weight. For example, 9.7% of men and 22.1% of women of all races and ages perceive themselves as overweight, while 29.2% of men and 56.6% of women actually are overweight.[4] Only 16% of black South African women perceived themselves as overweight compared to 34% of women of mixed ancestry, 31% of Indian women, and 54% of white women. Therefore, it appears that when analysed by gender and ethnicity, only white South African women are able to perceive their actual body weight accurately.[4] Differences in the findings of these studies may relate to cultural factors.

Mvo *et al*.[110] and Clark *et al*.[111] have shown that an overweight body type has positive connotations within the black South African community, symbolising happiness, beauty, affluence, health and a negative HIV/Aids status. The racial difference in body image perception appears to stem from adolescence as Caradas *et al*.[112] found that the ideal body size desired by white girls was significantly smaller than that of the mixed race or black girls. Furthermore, dissatisfaction with present body size was significantly higher in white, compared to black or mixed race girls.[112] Additionally, a study of 150 black and white college students enrolled at the University of Natal showed that black men had significantly higher scores than white men on the Eating Disorder Inventory (EDI), suggesting that there could be a higher prevalence of eating disorder pathology in black men.

4.6 Education

The level of education appears to be related to overweight and obesity.[4,114] The national SADHS found that incorrect perception of body weight was related to lower levels of education and that women with the smallest waists were the most educated.[4] This study also established that low educational status was associated with a higher BMI in black African women. Conversely, men with more than eight years' schooling had a significantly higher BMI than those with less or no schooling.[4] This research shows that level of education plays a role in the development of obesity in South Africa.

4.7 Parity

Parity is associated with obesity in women.[115-119] In the Health and Retirement study, which included 4 523 American couples, among women a 7% increase in risk of obesity was documented for each additional child. Interestingly, the same study found a 4% increase in risk of obesity in men, suggesting that perhaps lifestyle changes after the birth of a child may lead to increased prevalence of obesity in both sexes.[116] The Stockholm Pregnancy and Weight Development Study found that weight increase during pregnancy was the strongest predictor for sustained weight retention one year after birth. They noted an increase in reported lifestyle changes, such as changes in diet, exercise and meal patterns, in women who retained more weight postpartum than those who did not. This again suggests that body weight after pregnancy could be determined, in part, by lifestyle changes associated with having children.[119] However, studies have shown that BMI prior to pregnancy,[117] young age at menarche, maternal age, time period from menarche to first birth and high gestational weight gain are important in determining the risk of becoming overweight after pregnancy.[120]

4.8 Stress

High levels of stress are associated with increased weight gain. Overgaard *et al*.[121] found that psychological workload was associated with higher weight gain in a sample 6 704 female Danish nurses, who were studied between 1993 and 1999. Dallman *et al*.[122] recently proposed a novel theory regarding chronic stress, comfort food and weight gain. They proposed that stressed or depressed people who have a decreased cerebrospinal corticotrophin-releasing factor, catecholamine concentrations, and hypothalamo-pituitary-adrenal activity may overeat to reduce the activity in the chronic stress response network.

South African research has shown that the stress of urbanisation may lead to increased incidence of chronic diseases of lifestyle. Steyn *et al*.[123] reported that in a sample of 986 black African men and women, aged 15-64 years living in the Cape Peninsula, those who spent larger proportions of their lives in an urban setting tended to have unhealthier lifestyles and higher risk for chronic diseases of lifestyle when compared to those who were less urbanised.

Taken together, these data suggest that there are certain environmental and socio-cultural factors contributing to the development of obesity in South Africans, and in particular, younger persons that may provide the basis for targeted public health intervention.

5. ADDRESSING THE PROBLEM: POLICY ENVIRONMENT AND THE INTERFACE BETWEEN GOVERNMENT AND CIVIL SOCIETY IN SOUTH AFRICA: STRATEGIES TO PREVENT AND MANAGE OBESITY

The South African policy environment for the prevention and management of chronic diseases of lifestyle reflects the epidemiological and health transition of this country, and the concomitant democratisation of South Africa, along with its rapid urbanisation. In 1996 the Directorate, Chronic Diseases, Disabilities and Geriatrics, was activated by the Department of Health and the first director was appointed. Over the past nine years, the Ministry of Health has completed a consultative process to develop a series of guidelines for the prevention or management of non-communicable diseases, including separate guidelines for the prevention and management of diabetes, hypertension, hyperlipidaemia and overweight. In addition, national food-based dietary guidelines were launched in 2004 and, more recently, in November 2004, the Directorate of Health Promotions, within the Department of Health, launched an inter-sectoral strategy aimed at the Promotion of Healthy Lifestyles and change from risky behaviour, particularly among the youth. This forms part of a plan for comprehensive health care in South Africa, and is one of the strategic priorities for the period 2004-2009.

In support of this initiative, the Department of Health has embarked on a programme of surveillance incorporating health indicators, such as BMI, physical inactivity and blood pressure.

This nationally representative survey that was first carried out in 1998, has been repeated in 2003-2004.[4] This survey provided the basis of the first published data concerning the South African national prevalence of overweight and obesity, and highlighted this problem as a major public health issue.[4] This will provide a means by which secular trends for these health indicators can be monitored, in response to the national health strategy.

Government has recently engaged, particularly at a multi-sectoral level, in the promotion of physical activity for health, via the education sector, and at a population level, through "Vuka-South Africa" or "Move for your Health". One of the target outcomes of this intervention is the awareness of the association between physical activity and maintaining an optimal weight. However, as with many programmes at both government and non-governmental level, there is often a failure to measure impact and effectiveness, or to provide adequately for implementation. This issue is currently being addressed in these initiatives by actively collaborating with the private sector.

In the private sector, there is increasing recognition of the complex nature of obesity prevention and management, and as such, over the past five years, continuing education has been provided at a professional level for doctors, nurses and other allied health professionals, through various foundations and professional bodies. Another important initiative in the private sector is the introduction of "wellness" programmes from major health insurers. These programmes encourage ongoing health-risk appraisal, including measurement of BMI and body fat levels, and reward and recognise maintaining a healthy weight, or engaging in appropriate weight loss strategies.

CONCLUSIONS AND RECOMMENDATIONS

From this review, it is apparent that obesity in South Africa is a growing problem in all sectors of the community, yet a particular challenge in children and urbanised black women. To address this problem and the associated morbidities in South African communities, a multi-sectoral approach is needed. This should include changes in policy aimed at creating an environment conducive and supportive for change, such as the promotion of physical activity and dietary education in schools. In addition, the opportunity for primordial prevention of obesity, particularly in children, should be promoted. These prevention strategies should be culturally sensitive and encompass programmes to improve the education, status and economic empowerment of women.

Future research should focus on intervention strategies aimed at reducing obesity and its morbid sequelae. These strategies should be culturally specific, with a particular focus on children and women, and should include dietary and behavioural aspects, as well as interactions with pharmacotherapy.

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