The effect of regular increased physical activity, and regular consumption of Ready-To-Eat-Cereal (RTEC) breakfasts and afternoon snacks on the weight of young adolescents attending public Gauteng schools

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Declaration

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Date: 1 September 2008

Androulla Philippou

Abstract

Obesity is recognizably a chronic disease worldwide and childhood obesity has considerable implications for long-term health. Manipulation of modifiable lifestyle variables, such as high-fat energy-dense diets and decreased physical activity are often recommended for positive (although not always significant) outcomes.

This study aimed to determine the specific relationships between ready-to-eat cereals (RTEC) consumption (regular RTEC breakfast consumption and regular RTEC afternoon snack consumption), regular increased physical activity, and anthropometric measures [body weight, percentage body fat, and body mass index (BMI)] amongst young adolescents attending public Gauteng schools.

A randomised controlled trial was conducted over 5-weeks amongst 212 cross-cultural, male and female, English speaking children aged 10-13 years attending two selected public Gauteng schools. Participants were randomly allocated to one of four cohorts (Control, Step, RTEC or Step & RTEC). The control cohort had no prescribed intervention, the Step cohort had prescribed stepping intervention only (completion of 2 000 additional steps in a 20-minute period on 3 school days per week), the RTEC cohort had prescribed RTEC consumption intervention only (consumption of a single RTEC serving at breakfast and RTEC snack serving as an afternoon snack on each school day), and the Step & RTEC cohort had both the prescribed stepping and RTEC consumption interventions. Participants were assessed anthropometrically at baseline and at the end of the 5 weeks. They also submitted a food/activity diary from which quantitative measures of their intake and activity were determined.

The Step (107 845 ± 31 251) and Step & RTEC (108 793 ± 26 285) cohorts both completed significantly more mean total steps than Control (83 501 ± 22 302) and RTEC (86 082 ± 23 367) cohorts ($p \leq 0.01$), and a significant negative correlation ($p=0.02$; $r=-0.21$) was found between the change in percentage body fat and the total steps completed. The Step & RTEC (14.32 ± 7.95) and RTEC (16.06 ± 8.82) cohorts consumed more RTEC snack servings as afternoon snacks than Control (1.13 ± 1.69) and Step (1.59 ± 2.50) cohorts ($p \leq 0.01$), and a significant negative correlation ($p=0.03$; $r=-0.20$) was found between the participants' change in weight and the servings of RTEC snacks consumed as an afternoon snack. No significant difference ($p=0.35$) was achieved in mean weight change across the four cohorts, although both Step & RTEC (-0.12 ± 0.81) and RTEC (-0.24 ± 0.77) cohorts showed a mean decrease in body weight. No significant difference ($p=0.47$) was achieved in

mean change in percentage body fat across the four cohorts either, although all cohorts showed a decrease in percentage body fat, with Step cohort (-0.32 ± 0.70) showing the greatest mean change.

The stepping intervention alone brought about greatest decrease in percentage body fat, while the RTEC consumption intervention alone brought about greatest decrease in body weight and BMI. The combination of interventions was the least effective of the three interventions in bringing about decreases in percentage body fat.

Opsomming

Vetsug word wêreldwyd erken as ‘n chroniese siektestoestand en kinder-vetsug het aansienlike implikasies op langtermyn gesondheid. Manipulering van wysigbare lewenstyl veranderlikes soos hoë vet, energie-digte diëte en verlaagde fisiese aktiwiteit, word dikwels aanbeveel vir positiewe (hoewel nie altyd beduidende) uitkomste.

Die doel van die studie was om die spesifieke verwantskap tussen reg-om-te-eet grane ("RTEC") inname (gereelde RTEC ontbyt inname en gereelde RTEC middag versnapering inname), gereelde verhoogde fisiese aktiwiteit, en antropometriese metings [liggaamsgewig, persentasie liggaamsvet en liggaamsmassa indeks (LMI)] te bepaal, in ‘n groep jong adolessente wat publieke Gauteng skole bywoon.

‘n Ewekansige gekontroleerde studie was uitgevoer oor ‘n tydperk van 5 weke, insluitend 212 multi-kulturele, manlike en vroulike, Engelssprekende kinders tussen die ouderdomme van 10-13 jaar, wat twee geselekteerde publieke Gauteng skole bywoon. Die deelnemers was ewekansig toegewys tot een van vier kohorte (Kontrole, “Step”, “RTEC” of “Step & RTEC”). Die Kontrole kohort het geen voorgeskrewe intervensie gehad nie, die “Step” kohort het slegs ‘n voorgeskrewe stap intervensie gehad (voltooiing van 2000 addisionele treë binne 20 minute vir 3 skool dae per week), die RTEC groep het slegs die voorgeskrewe “RTEC” inname intervensie gehad (inname van ‘n enkele “RTEC” porsie tydens ontbyt en ‘n “RTEC” versnaperingsporsie as ‘n middag versnapering tydens elke skooldag), en die “Step & RTEC” kohort het beide die voorgeskrewe stap en RTEC inname intervensies gehad. Deelnemers was antropometries geassesseer by basislyn en aan die einde van die 5 weke. Die deelnemers het ook elkeen ‘n voedsel/aktiwiteit dagboek ingehandig waarvan kwantitatiewe bepalings van hul inname en aktiwiteit bepaal is.

Die “Step” (107 845±31 251) en die “Step & RTEC” (108 793±26 235) kohorte het beide gemiddeld betekenisvol meer treë gegee as die Kontrole (83 501±22 302) en “RTEC” (86 082±23 367) kohorte ($p \leq 0.01$). Daar was ‘n betekenisvolle negatiewe korrelasie ($p=0.02$; $r=0.21$) tussen die verandering in persentasie liggaamsvet en die totale aantal treë gegee. Die “Step & RTEC” (14.32±7.95) en “RTEC” (16.06±8.82) kohorte het meer van die “RTEC” versnaperingsporsie as namiddag happie geëet as die Kontrole (1.13±1.69) en “Step” (1.59±2.50) kohorte ($p \leq 0.01$). Daar was ‘n betekenisvolle negatiewe korrelasie ($p=0.03$; $r=-0.20$) tussen die deelnemers se verandering in gewig en die porsie van die “RTEC” versnapering wat as namiddag happie geëet is. Daar was geen betekenisvolle verskil ($p=0.35$) in die gemiddelde gewigsverandering in die vier kohorte nie, alhoewel die “Step & RTEC” (-0.12±0.81)

en “RTEC” (-0.24±0.77) kohorte ‘n gemiddelde afname in liggaamsgewig getoon het. Die gemiddelde verandering in persentasie ligaamsvet het ook geen betekenisvolle verskil (p=0.47) getoon in die vier groepe nie, alhoewel al vier groepe ‘n verlaging in die persentasie liggaamsvet aangetoon het, met die “Step” (-0.32±0.70) kohort wat die grootste gemiddelde verandering getoon het.

Die “Step” intervensie alleen het die grootste verlaging in die persentasie liggaamsvet veroorsaak, terwyl die “RTEC” inname intervensie alleen gelei het tot die grootste verlaging in liggaamsgewig en LMI. Die kombinasie van intervensies was die minste effektief van die drie intervensies om die persentasie liggaamsvet te verlaag.

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LIST OF ABBREVIATIONS

AAP	American Academy of Paediatrics
ADA	American Dietetic Association
AHA	American Heart Association
AI	Adequate Intake
AIDS	Acquired Immune Deficiency Syndrome
ANOVA	Analysis of Variance
BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
BMR	Basal Metabolic Rate
Bt20	Birth to Twenty cohort
CART	Cocaine Amphetamine Regulated Transcript
CATCH	Child and Adolescent Trial for Cardiovascular Health study
CDC	Centers for Disease Control and Prevention
CHD	Coronary Heart Disease
CHIPs	Community Health Intervention Programmes
CI	Confidence Interval
Cp	Precision (statistical abbreviation)
CSFII	Continuing Survey of Food Intake by Individuals
DEXA	Dual-energy X-ray absorptiometry
DHS	National Demographic and Health Study
FAO	Food and Agriculture Organisation
FBDG	Food-Based Dietary Guidelines
FFM	Fat Free Mass
FGP	Food Guide Pyramid
GDE	Gauteng Department of Education
GI	Glycemic Index
GL	Glycemic Load
GUTS	Growing Up Today Study
HDL	High-density lipoprotein
HIV	Human Immuno-deficiency Virus
IOTF	International Obesity Task Force
Kcal	Kilocalories
LBM	Lean Body Mass

LDL	Low-density lipoprotein
NCDs	Non-communicable diseases
NFHCS	National Food and Health Consumption Survey
NHANES	National Health Examination Survey
NIH	National Institutes of Health
NPY	Neuropeptide Y
OPPrA	Stanford Obesity Prevention for Pre-Adolescents trial
PAR	Population Attributable Risks
PC_1	Pro-hormone convertase 1
PDPAR	Previous Day Physical Activity Recall
PPARγ2	Peroxisome-proliferator-activated receptor γ2
PTA	Parent Teachers Association
RDA	Recommended Dietary Allowance
REE	Resting Energy Expenditure
RMR	Resting Metabolic Rate
RTEC	Ready-to-Eat Cereal
SA	South Africa
SASOM	South African Society for Obesity Management
SASSO	South African Society for the Study of Obesity
SD	Standard Deviation
SES	Socio-economic Status
TEE	Total daily Energy Expenditure
THUSA	Transition and Health during Urbanisation of South Africans
UCLA	University of California
UHT	Ultra-high temperature
US	United States
USDA	United States Department of Agriculture
WHO	World Health Organisation
YRBSS	Youth Risk Behavior Surveillance System

LIST OF DEFINITIONS

Adequate Intake (AI)

This refers to the recommended daily intake level of a particular macro- or micro-nutrient, based on observed or experimentally determined approximations of the nutrient intake by a group (or groups) of healthy people. These nutrient recommendations are used when a recommended dietary allowance (RDA) cannot be determined.[1]

Afternoon Snack

According to the Concise Oxford Dictionary,[2] a snack can be defined as a light, casual, or hurried meal. It is usually a small amount of food eaten between main meals. For the purpose of this study, an afternoon snack referred to a snack consumed between lunch and dinner. It included a Kellogg's Cornflake or Coco pop cereal and milk bar (as the RTEC serving), which acted as a low fat, sweet, carbohydrate based snack.

Basal Metabolic Rate (BMR)

This is the measurement of an individual's basal energy expenditure (BEE), usually expressed as kilocalories per kilogram of body weight (kcal/kg). The BEE refers to the amount of energy used in 24 hours by a person who is physically (ie. lying down) and mentally resting, 12 to 18 hours after their last meal, in a thermo-neutral environment that prevents the activation of heat-generating processes such as shivering.[3]

Baseline Daily Physical Activity

For the purpose of this study, baseline daily physical activity referred to the number of daily steps recorded by the pedometer during the course of each school day.

Bio-electrical Impedance Analysis (BIA)

This refers to a body composition analysis technique based on the principle that compared to fatty tissue, lean tissue has a higher electrical conductivity and lower impedance, relative to water, based on electrolyte content.[4] It involves attaching electrodes to the extremities of the patient's body and passing a small current through the electrodes to obtain the electrical resistance measurements.[4]

Breakfast

According to the Concise Oxford Dictionary,[2] breakfast can be defined as the first meal of the day. For the purpose of this study, breakfast was further defined as the first meal of the day, usually taken before the start of the school day.

Dual-Extra Absorptiometry (DEXA)

This refers to a novel scanning technique that accurately estimates bone mineral, fat, and fat-free soft tissue, with minimal radiation exposure.[3]

Fat free mass (FFM)

This refers to tissue that is devoid of all extractable fat, and can only be measured accurately by direct carcass analysis.[5]

Glycemic Index (GI)

The GI is defined as the incremental area under the blood glucose response curve of a 50g carbohydrate portion of a test food, expressed as a percentage of the response to the same amount of carbohydrate from a standard food (usually white bread or glucose [6]), taken by the same subject, and the measurement of the GI value of any particular food item needs to be done *in vivo* using an established protocol as done by the World Health Organisation (WHO) and Food and Agriculture Organization (FAO).[7] The *in vivo* measurement determines the relative rate of entry of the glucose from the test food into the bloodstream.[8]

Glycemic Load (GL)

This refers to the effect of a serving of carbohydrate-containing food on glycemia, as it represents the quality of the carbohydrate-containing food (the glycemic index) and the quantity of that food (the weight).[8]

Lean Body Mass (LBM)

This refers to the part of the body that is free of adipose tissue, and includes the skeletal muscles, water, bone, and a small amount of essential fat in the internal organs, bone marrow and nerve tissues. It can thus be determined clinically.[5]

Loving Lifestyle

This term was designed as a program name specifically for the purposes of this study, allowing the participants to identify themselves as part of an identifiable program with positive connotations, as opposed to simply being part of a study.

Pedometer

A pedometer refers to a step counter which counts walking steps according to the movement of the waist. [9] The specific pedometer used in this study was sponsored by Kellogg's.

Overweight and Obesity

The International Obesity Task Force (IOTF) supports the use of the body mass index (BMI), calculated as per the formula of weight (kg) / [height (m)]^2, to assess fatness or adiposity in children and adolescents.[10] In 2000, a new definition of overweight and obesity in childhood, based on pooled international data for BMI and linked to the adult obesity cut off point of 30 kg/m^2 was proposed by Cole,[11] based on the premise that a cut-off point related to age allows for a more accurate definition of childhood obesity, since BMI in childhood changes substantially with age.

Population Attributable Risks (PAR)

Population Attributable Risk is also known as the attributable fraction or aetiologic fraction, and indicates the reduction in disease in the whole population that might be achieved by eliminating a particular risk factor.[12]

Public Gauteng Schools

This referred to all schools listed as public schools, as per the records of the Gauteng Department of Education (GDE) at the time of the data request, during April 2006. More specifically, for the execution of this study, two public schools from the Ekhurhuleni East and West districts of Gauteng were included, based on location convenience and consent by the respective headmasters to allow their pupils to participate in the study.

Ready-To-Eat (RTE) Breakfast Cereals

RTEC or the 'dry' breakfast cereals are processed cereal grain products that are made up of either flaked, gun puffed, oven puffed, extruded, shredded, or granola and are made from wheat, corn, rice, oats and other grains. They are precooked and are usually consumed with milk.[3]

The RTECs stipulated for use by the participants of the 2 RTEC intervention cohorts in this study, were the Kellogg's range of intermediate-GI RTECs. The complete intermediate-GI range includes Kellogg's Honey Nut Crunch All-Bran Flakes, Kellogg's Strawberry Pops, Kellogg's Hunny B's, Kellogg's Frosties, Kellogg's Coco Pop Crunchers, Kellogg's Coco Pops and Kellogg's All-Bran Flakes (without skimmed milk). For the purpose of this study however (due to sponsorship by the Kellogg's Company), only Kellogg's Frosties, Kellogg's Coco Pop Crunchers and Kellogg's Strawberry Pops were used by the participants of the 2 RTEC intervention cohorts.

Ready-To-Eat Cereal Serving

As per the recommendations of the South African Nutrition Experts Panel, a single serving of RTEC is 40 g.[13] Depending on the RTEC consumed, the volume of 40 g RTEC may differ. A reference list was compiled at the end of the 5-week study period to quantify single 40 g RTEC servings (as volumes) of all the recorded RTE cereals (Addendum 1). For the purpose of this study, a 40g portion of the intervention cereals (Kellogg's Strawberry Pops, Coco Pop Crunchers and Frosties) was equivalent to a volume of 250 ml.

Ready-To-Eat Cereal Snacks

RTEC snacks in this study referred to any food item other than RTE breakfast cereals, in which the primary ingredient was a RTE breakfast cereal. The RTEC snacks that were stipulated for use by participants of the 2 RTEC intervention cohorts in this study were the Kellogg's range of 'Anytime' snack bars. The complete range included the Special K red berries, peach and apricot bars; the All-Bran original bars; the All-Bran cranberry bars; the Rice Krispies Treats (original) (no longer manufactured); the Coco Pops cereal and milk bars; and the Corn Flakes cereal and milk bars. The primary ingredient in each of these bars was the Ready-To-Eat breakfast cereal after which each bar type is named. For the purpose of this study (due to sponsorship by the Kellogg's Company), only the Coco Pops and Cornflake cereal and milk bars were used by the participants of the 2 RTEC intervention cohorts.

Ready-To-Eat Cereal Snack Serving

As per the recommendations of the South African Nutrition Expert Panel, a single serving of a RTEC snack was equivalent to one RTEC snack bar.[13]

Recommended Dietary Allowance (RDA)

This refers to the amount of a nutrient that is needed to meet the requirements of nearly all (97% to 98%) of the healthy population.[1]

Regular Consumption of RTEC (RTEC Consumption Intervention)

Regular consumption of a RTEC breakfast and snack referred to the consumption of a single serving of supplied Kellogg's intermediate-GI RTEC (Frosties, Strawberry Pops or Coco Pops Crunchers) with low fat milk for breakfast, and a supplied RTEC Kellogg's snack bar (Coco Pops or Cornflakes) as an afternoon snack, on each weekday of the five-week study period.

Regular Increased Physical Activity (Stepping Intervention)

Regular increased physical activity (for the purpose of this study) referred to the total number of additional steps completed on each day of the 5-week study period, where the target for the increased regular physical activity was defined as the completion of a minimum of 2 000 steps in a 20-minute exercise session, on each of three weekdays, during each of the five weeks of the study period, as measured by a pedometer that was worn by the participant during the course of each school day.

Resting Energy Expenditure (REE)

This refers to the energy expended for the maintenance of normal body functions and homeostasis, and represents the largest portion of total energy expenditure.[3]

Resting Metabolic Rate (RMR)

This is the measurement of an individual's resting energy expenditure, usually expressed as kilocalories per kilogram of body weight (kcal/kg).[3]

Total Energy Expenditure (TEE)

Total Energy Expenditure refers to the sum of the resting energy expenditure, energy expended in physical activity, and the thermic effect of food, and refers to the energy expended by an individual in 24 hours.[3]

Young Adolescents

The World Health Organisation (WHO) classifies individuals between the ages of 10 – 19 years as adolescents,[14] and hence in this study, young adolescents referred to those individuals at the beginning of this pre-defined age spectrum. In other words, 'young adolescents' referred to individuals in the last three grades of primary school (ie. grades five, six, and seven), where the age was expected to be between 10 – 13 years old.

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CHAPTER 1: REVIEW OF RELATED LITERATURE

1.1 INTRODUCTION

Dr Wacogne, a paediatric consultant at Birmingham Children's Hospital in the United Kingdom, made a statement that echoes in disturbing truth. He commented that 'by current trends, it's looking like, by the year 2050 we'll all be 150kg by our thirtieth birthday, and the only exercise we'll get is activating the direct computer access to McKFC for our next order of a pork fat thick shake'. He continued by saying that 'our children are getting fatter, doing less exercise and eating worse and worse foods'.[15]

1.2 THE OBESITY EPIDEMIC IN CHILDREN AND ADOLESCENTS

A press release in 1997 by the World Health Authority of the World Health Organisation (WHO) stated that millions of people were at risk of developing obesity-associated co-morbid diseases, based on the 1.5 billion people classified as being overweight worldwide at the time. The WHO then issued a warning statement that immediate action would be required to curtail the growing epidemic of overweight and obesity,[11,16] and in 1998, the WHO elected obesity as a global epidemic.[17,18] James and colleagues, stated in 2001 that obesity is recognised as a chronic disease, with approximately half of the world's adult population being affected by either overweight or obesity (defined here as a BMI>25 kg/m^2).[19] In 2001, the American Surgeon General also stated that 'overweight and obesity may soon cause as much preventable disease and death as cigarette smoking'.[16,20]

In the United States specifically, childhood obesity is the most extensive and severe nutritional problem, with varying prevalence rates amongst the various ethnic groups.[21,22] Recently released data from National Health Examination Survey (NHANES-IV), indicated that the prevalence of obesity (defined as the body mass index (BMI) $\geq 95^{th}$ percentile of the 2000 CDC (Centers for Disease Control and Prevention) growth charts), has tripled from 4% in 1963 to 1965 to 13% in 1999 and has increased from 5% in 1966 to 1970 to 14% in 1999, among children aged 6 to 11 years and adolescents aged 12 to 19 years respectively.[20,21] According to the CDC's National Center for Health Statistics, Rampersaud and colleagues reported that in the past twenty years alone, the occurrence of overweight in the United States (US) has doubled in children, and has nearly tripled in adolescents.[23]

Within the South African context explicitly, Du Toit and colleagues highlighted an active nutrition paradox, where under- and over-nutrition are both dynamically existent, and where children are at an active risk of developing either of these two completely disparate disease conditions.[16] Findings from the 1999 National Food and Health Consumption Survey (NFHCS) showed that the highest prevalence of stunting and underweight were found in rural areas and especially amongst children between the ages of 1 to 3 years.[24] The highest prevalence of overweight, however, was found in urbanised areas and amongst children between the ages of 1 to 3 years.[24] The NFHCS also showed that the national prevalence of overweight (defined as weight/height > 2 standard deviations) among children between the ages of 1-9 years was 6% (the Mpumalanga province revealing the highest figure of 17%), while only 5% of children were 'wasted' (an indicator of acute malnutrition) and approximately 25% 'stunted' (an indicator of chronic malnutrition).[24] The Birth to Twenty (Bt20) cohort showed that 9% of the black female adolescents investigated at age 13 were overweight and a further 6% of these adolescents were obese.[25] In 2006, the Health of the Nation Study then revealed that the prevalence of obesity within a greater sample of South African children (selected randomly from primary schools in five of the countries provinces) aged between 6 and 13 years was 3.2 % for the males and 4.9% for the females.[26] The prevalence of overweight amongst these children was 14.0% for the males and 17.9% for the females.[26]

When South African datasets (based on data from 2001 through to 2004) on the percentage of children classified as overweight or obese were compared with similar datasets from the US, South African children were found to currently show rates of overweight and obesity that are analogous with the rates demonstrated by children in the US between 1976 and 1980.[26] South African boys were somewhat lower, and South African girls are slightly higher than the rates from the above-mentioned US dataset.[26] When South African children were divided into their ethnic groups, and compared to the prevalence of overweight and obesity in the US between 1988 and 1994, the prevalence rates amongst the white South African children and the black girls were comparatively close to those of the US.[27] The black South African boys however, were found to be less than half as likely as their US counterparts to be overweight.[27]

These trends of overweight and obesity across the world and in our very own country provide us with hints of insight concerning the national versus international extent of the problem, and a foundation of comparison from which standards of management and monitoring can and should be developed.

1.2.1 Definition of Overweight and Obesity

In the US, the cut-off values of 85th and 95th percentiles of BMI for age and sex are used to define overweight and obesity.[28] Since these values, however, are exclusively based on nationally representative survey data from the US alone, they are a long way from being universally suitable and acceptable.[11] According to Cole and colleagues, while the public health importance of closely monitoring childhood obesity trends is evident, the wide range of definitions of child obesity in use makes it difficult to quantify or evaluate international trends [11].

Recently, the International Obesity Task Force (IOTF) assembled a workshop on childhood obesity to establish some consensus on the most appropriate measurement to be used for the assessment of the global prevalence of obesity in populations of children and adolescents.[28] An assortment of subjects related to this problem was considered at the workshop, including the fact that model measurements of body fat in populations, should be reliable and compare well with body fat in both sexes and across all ages and ethnic groups.[28] While measures such as triceps skinfold thickness offer direct measurements of subcutaneous fat and are relatively well correlated with percentage body fat,[11,28] measurements by various observers and measurements of fatter subjects are difficult to reproduce.[28] Determination of percentage body fat itself is not considered to be feasible in an epidemiological context.[11] It was however concluded at the workshop that since individuals of different heights or body builds can indeed have similar fat masses in spite of substantially different proportions of total body fat, and since obesity refers to a condition of excess body fat, body fat expressed as a percentage of body weight (percentage body fat) is in fact the most pertinent measure against which other anthropometric measurements should be correlated.[28]

That having been said, a variant of weight-for-height (based on the higher reliability of weight and height measurements) is considered to provide a more reliable measure of adiposity, and furthermore, a measure that can be used to compare adiposity within and between populations.[28] Measurements of body composition in children and adolescents with which anthropometric measures can be correlated have usually been based on measurements of body density, as determined by underwater weighing or dual-energy X-ray absorptiometry (DEXA).[28] Using these measurements, correlation coefficients between percentage body fat and BMI have been found to be comparable among young boys and girls and lower among older boys than among older girls.[28] The study by Daniels and colleagues is the only study to have examined subjects by pubertal staging, and they suggested that mature boys had less body fat than girls at similar BMI's.[29] These changes could be considered in understanding the decreased associations between percentage body fat and BMI in the older boys investigated.

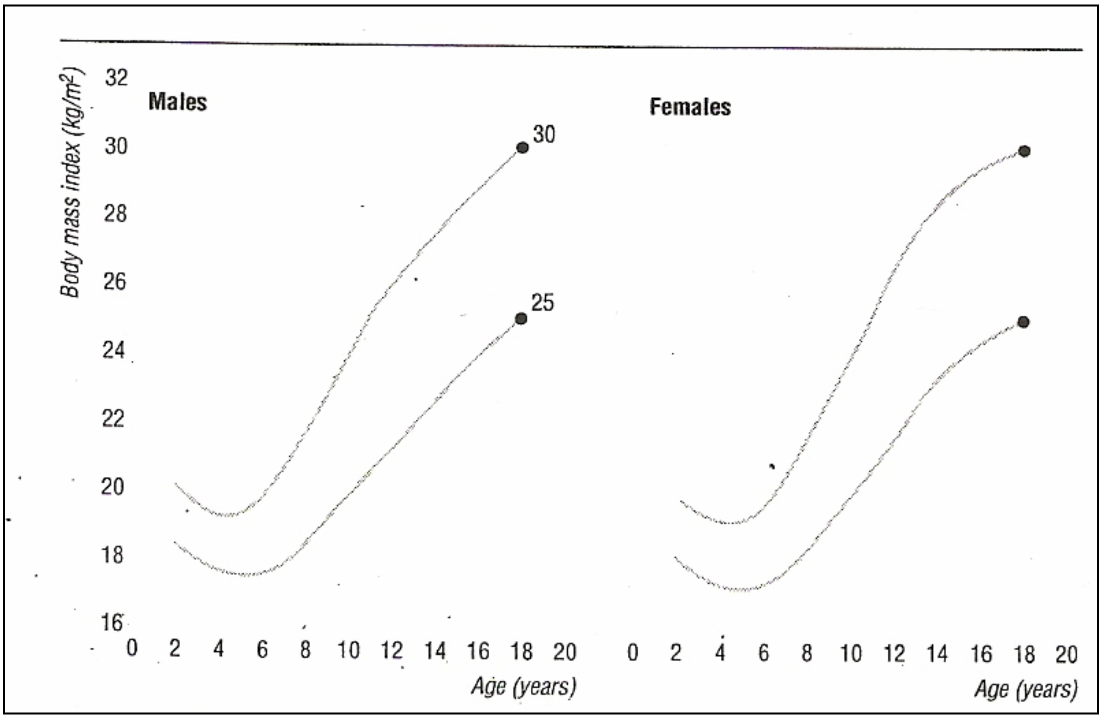
Daniels and colleagues also examined children and adolescents in non-white racial or ethnic groups, and found comparable correlation coefficients between percentage body fat and BMI for white and black children.[29] They did however find that inclusion of race and ethnicity compounded their findings significantly, such that black children had lower percentages of body fat than did their white

BMI-matched counterparts.[29] This finding was supported by a similar study by Yanovski and colleagues.[30]

According to Dietz and Bellizzi,[28] there are also at least two other problems which potentially perplex the use of BMI as a measure of adiposity in different populations. Firstly, since the existing records from which the correlation coefficients were extracted apply only to non-obese children and adolescents, the data does not eliminate the prospect that a BMI above the 95th percentile might provide a more specific measure with which children and adolescents with increased body fat can be identified.[28] Critical insight into the validity of these BMI cut-off points for the evaluation of obesity can thus be obtained through the calculation of the sensitivity and specificity of a BMI above the 85th and 95th percentiles for an increase in percentage body fat.[28] Secondly they suggest that previous undernutrition may affect the validity of the BMI. This is based on the findings of multiple studies with significant prevalence's of undernutrition whereby factors other than increased body fat may be responsible for the increased weight-for-height ratio amongst stunted children.[28]

The workshop nevertheless concluded that BMI in kg/m^2 offers a practical measure for the assessment of fatness in children and adolescents, and that the standards used to recognise overweight and obesity in children and adolescents should concur with the standards used to recognise grade 1 and grade 2 overweight (BMI of 25 and 30 kg/m^2, respectively) in adults. This in turn provides a consistent measurement of obesity across the individual's lifespan.[28] This resolution was based on the records from many countries in Europe and North America,[28] but none from Asia and Africa.[17] Validation studies in these other populations are therefore still needed.

In 2000, a new definition of overweight and obesity in childhood, based on collective international data for BMI and linked to the adult obesity cut-off point of 30 kg/m^2, was suggested.[11] It was based on the presupposition that since BMI in childhood alters considerably with age (for example, at birth the median is as low as 13 kg/m^2, increases to 17 kg/m^2 at age 1, decreases to 15.5 kg/m^2 at age 6, and then again increases to 21 kg/m^2 at age 20), it would seem appropriate to use a cut-off point that is related to age when defining childhood obesity.[11] This definition was founded on the data of six large nationally representative cross sectional surveys on growth and the BMI for children from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the US.[11] The reference population was acquired by determining the mean of the centile curves across a heterogenous mix of surveys from the different countries (Figure 1.1), with their vastly different prevalence rates for obesity, and the appropriate cut-off points were defined as BMI units in young adulthood, which were then extrapolated to childhood (Table 1.1).[11] Considerations were made to conserve the corresponding centile in each dataset.[11]



***Source:* Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesityworldwide: international survey. BMJ. 2000;320:1-6.**

Figure 1.1: International cut-off points for body mass index for overweight and obesity by sex, passing through body mass index 25 and 30 kg/m^2 at age 18 (averaged data from Brazil, Britain, Hong Kong, Netherlands, Singapore and United States)

Table 1.1: International cut-off points for body mass index for overweight and obesity by sex between 2 and 18 years, defined to pass through body mass index of 25 and 30 kg/m² at age 18

	Body mass index 25 kg/m²		Body mass index 30 kg/m²	
Age (years)	**Males**	**Females**	**Males**	**Females**
2	18.4	18.0	20.1	20.1
2.5	18.1	17.8	19.8	19.5
3	17.9	17.6	19.6	19.4
3.5	17.7	17.4	19.4	19.2
4	17.6	17.3	19.3	19.1
4.5	17.5	17.2	19.3	19.1
5	17.4	17.1	19.3	19.2
5.5	17.5	17.2	19.5	19.3
6	17.6	17.3	19.8	19.7
6.5	17.7	17.5	20.2	20.1
7	17.9	17.8	20.6	20.5
7.5	18.2	18.0	21.1	21.0
8	18.4	18.3	21.6	21.6
8.5	18.8	18.7	22.2	22.2
9	19.1	19.1	22.8	22.8
9.5	19.5	19.5	23.4	23.5
10	19.8	19.9	24.0	24.1
10.5	20.2	20.3	24.6	24.8
11	20.6	20.7	25.1	25.4
11.5	20.9	21.2	25.6	26.1
12	21.2	21.7	26.0	26.7
12.5	21.6	22.1	26.4	27.2
13	21.9	22.6	26.8	27.8
13.5	22.3	23.0	27.2	28.2
14	22.6	23.3	27.6	28.6
14.5	23.0	23.7	28.0	28.9
15	23.3	23.9	28.3	29.1
15.5	23.6	24.2	28.6	29.3
16	23.9	24.4	28.9	29.4
16.5	24.2	24.5	29.1	29.6
17	24.5	24.7	29.4	29.7
17.5	24.7	24.8	29.7	29.8
18	25	25	30	30

Source: *Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320:1-6.*

While there is probably adequate reflection of Western populations in this definition, this international measure again lacks representation from places like Africa and Asia. These parts currently do not have any known or datasets which are able to meet the denoted criteria for dataset inclusion.[11] This includes a large sample, national representativeness, minimum age range 6 to 18 years, and quality data control.[11] Cole and colleagues however state that the grave need for international cut-off points right now does not render waiting for such surveys to be completed a pragmatic option.[11]

Although this approach still only provides a statistical definition (presenting with all the implied and known advantages and disadvantages of such an approach), and even though the health consequences for children above the cut off points may still differ from those of adults, these cut-off points are intended to be widely applied in an attempt to determine whether the children and adolescents that they identify are in fact at increased risk of morbidity related to obesity.[11] It can be considered to be less subjective and more international than other approaches or definitions, and thus aims to encourage the intended direct comparisons of trends in child obesity worldwide.[11]

1.2.2 Causes of Obesity Worldwide and Within the South African Setting

Obesity is a multifactorial disease and its occurrence is due to compound interactions between genes and the environment, and its development is in fact a multipart phenomenon controlled and influences by several mechanisms and factors.[31]

1.2.2.1 Dietary patterns and causes of increased intake

To date, the principal causes of the increase in obesity worldwide can be considered as the combined effect of increased sedentary populations, together with the extensive availability of ever-mounting portions of high-calorie, low-nutrient foods (as seen by the enlarged per capita caloric consumption in the US specifically)[16,22,32] According to Young and colleagues,[22] dietary intake surveys illustrate a per capita increase of 200 kilocalories (kcal) per day from 1977-1978 to 1994-1996 in the US, and the US food supply (which refers to the total food produced, excluding the exports, and including the imports) provided 500 kcal/d per capita more in 2002, as compared to the 1970’s. The portions of foods available on the market have increased significantly since the 1970’s and surpass federal standards for dietary guidance and food labels.[22] In response to similar findings, the US Department of Agriculture (USDA) issued a statement identifying the gap between standard servings and typical portions, and the requisite for public health education interventions.[22] While multiple causes can be assigned to these portion size increases, most of the causes remain economic in nature.[22]

According to Young and colleagues,[22] there has also been an increase in the food consumed outside of the home. In 1970, this made up 34% of the food budget in the US, and increased to 47% by the late 1990’s. Taste, cost and convenience are often more likely to affect a consumers’ food selection than is health.[32] The food industry itself has increased in size since 1970, and with more people choosing to eat, the market has become more saturated and competitive.[22] This general price competition has consequently compelled manufacturers to introduce larger items as a means to maintain and inflate market share profits.[22] Oversized packaging's draw attention to new products, and bigger portions are usually seen as a bargain.[22] Interestingly, a survey conducted by the American Institute of Cancer Research revealed that Americans are inclined to ignore serving sizes when they are striving to maintain their body weight,[22] and this emphasises a clear lack of knowledge with regards to appropriate weight management practices.

Recent findings in the US have also indicated that the diets of many people are not succeeding in meeting the suggested number of servings from many of the groups of the Food Guide Pyramid (FGP), and instead they are attaining intakes that are too high in refined grains and added sugars and fats.[32] The FGP has consequently been criticised and linked to America's current obesity epidemic.[32] The Continuing Survey of Food Intake by Individuals (CSFII) data has however shown that lower BMI's have been correlated with people eating in a Pyramid-based dietary pattern compared with those eating in non-Pyramid patterns, as the Pyramid depicts a range of servings for each food group, whereby eating the minimum number of servings per day from each food group provides 1 600 kcal, eating at the midpoint of servings for each group supplies 2 200 kcal, and eating the maximum number of servings supplies about 2 800 kcal.[32]

One of the Food Based Dietary Guidelines (FBDG) of South Africa (SA) states that starchy foods should be made the basis of most meals.[33] This is an extension of the principles of the FGP, where the base of the pyramid (and largest contributing element of the diet) depicts carbohydrates and starches. This FBD guideline aims to encourage the most favourable intakes of cereals and grains such as oats, rice, sorghum, wheat and maize in the commercial forms of porridges, breads, rice, pastas, breakfast cereals and a variety of other items.[33] Although only 60 – 80% of excess energy will be stored in a situation of carbohydrate over-feeding (as compared to 96% in the case of fat over-feeding), it is however still possible to become obese on low-fat, high carbohydrate diets.[33] Thus the proposal of making starchy foods the basis of one's meals should always and unambiguously be complemented by recommendations to preferentially select unrefined or minimally processed cereals and grains.[33] A review of the current carbohydrate intakes of South Africans aged 25-65 years showed that the black South African population has the highest (although still acceptable) intake, followed by coloured South Africans, then white South Africans, and lastly Indian South Africans.[33]

The Bogalusa Heart Study has been gathering data on children's dietary intakes in a biracial community for more than 20 years. The macronutrient distribution of the children's diets in this community were found to be comparable to that of adolescents, with 13% of total energy coming from protein, 49% from carbohydrate, and 38% from fat.[34] Several studies on food intake in European children showed a general over-consumption of fat and protein (particularly of animal origin), and an under-consumption of fibre when compared to national recommended daily allowances.[31] When the nutritional status of South Africans from 1975 to 1996 was reviewed, white, coloured and Indian South Africans also surpassed the recommended total fat intake of 30% of total daily energy intake.[35] Specifically, 11 to 16 year old boys and girls of all ethnic groups in South Africa were found to be consuming diets with fat intakes contributing more than 30% of the total energy.[35]

The findings of the Bogalusa Heart Study indicated that school meals were playing a major impact on the diets of the children, whereby school breakfast and lunch together contributed approximately 50% of the day's total energy, protein, cholesterol, carbohydrate, and sodium intakes. Furthermore, approximately 40% of the daily total fat intake came from the school breakfast and lunch alone.[34] Since school breakfasts and lunches are not routinely provided by the schools in South Africa, the main contributor of the elevated fat intakes amongst the South African children needs to be identified elsewhere. The effects of increasing the variety of foods at a meal have been investigated, and it has been shown that more food is eaten when the variety of available food is high.[36] Data on sensory-specific satiety also suggests that increases in dietary variety leads to an increase in the variety of the sensory properties of food, which in turn leads to increased overall energy intake.[37] It is therefore possible that a contributing factor to the high fat intakes amongst the South African youth is the fact that with the increase in urbanisation, came an increased exposure to the propagated variety of foods currently available in the supermarkets.[38]

1.2.2.2 Energy and nutrient balance

According to Maffeis, the physiological growth of a child is genetically encoded such that all the major changes in body composition occur between birth and adulthood. Fat mass (conveyed as a percentage of body weight) increases from about 14 % at birth to about 25 % at 6 months of age, and then gradually decreases to its lowest point at around the age of 6 years. The fat mass then increases again until maturity.[31] A refined regulatory system controls this process, which functions to allow the individual to reach the best body composition needed to complete the work and reproductive responsibilities associated with typical adult life.[31]

Ravussin and colleagues, as discussed by Maffeis, explained that automatic, involuntary mechanisms are activated in humans when inadequate or excessive feeding occurs.[31] These aim to maintain the weight genetically planned for that individual exposed to that particular environment. In addition, Birch and colleagues stated that children appear to have a competent self-regulating mechanism of food intake which is able to stabilise their energy intake.[39] During the study by Birch and colleagues, the children had free access to preferred foods for a period of 6 days, and the outcomes did not show any great variations in their total energy intakes.[39]

Steyn et al reported that children between the ages of 1 and 3 years are most susceptible to chronic undernutrition and overnutrition, and it has been suggested that stunted children are in fact at a greater risk for being overweight.[24] This is based on the findings that stunted children have approximately twice the risk of being overweight as defined by a BMI > 25 kg/m^2). The reason for this remains largely unknown, although it has been suggested that nutritional stunting is affected by impaired fat oxidation or that nutritionally stunted children have impaired less efficient regulation of energy intake.[24] In children who become obese then, it is possible that this mechanism for the self-regulation of fat mass (if present) has not been effective.[31] Further data from Brazil suggested that stunting is more intimately associated with a greater vulnerability to the effects of high-fat diets.[40] While these various findings do not provide clear answers, Livingstone commented that epidemiological data has unmistakably shown how an increasingly larger cohort of children living in industrialised countries is failing to mimic physiological growth patterns, and presenting with a greater adiposity than that of the reference child.[41]

Although multiple genetic, metabolic and environmental factors may be included in the development of this phenomenon, the first law of thermodynamics dictates that each of the risk factors involved in fat gain must in some way endorse, as an epiphenomenon, a positive energy balance.[31] Even an extended minimal positive energy balance will bring about fat storage, and so slight changes in the mechanism of energy balance [defined as the difference between energy intake and total energy expenditure (TEE)] appear to be the main cause of fat gain and the increased occurrence of obesity.[31]

Energy is consumed and utilised by the body in the form of the macronutrients protein, fat and carbohydrate.[31] Carbohydrate and protein intake induce carbohydrate and protein oxidation respectively, and as previously mentioned, carbohydrates are not capable of inducing de novo lipogenesis, except in the case where extensive carbohydrate overfeeding occurs and the carbohydrate stores become fully saturated.[31] Fat intake however, is not able to bring about fat oxidation, and so fat balance is influenced by, and strictly reliant on, the balance of the other two nutrients.[31] This characteristic of the nutrient metabolism thus has an important impact on the pathophysiology of obesity, and suggests a pertinent responsibility of fat balance in the promotion of fat gain.[31] Fat storage occurs together with fat intake, such that ingested fat is preferentially stored with the exception of that which is oxidised.[31] This is independent of fat intake, but reliant on the quantity of carbohydrate and protein consumed and oxidised.[31]

Bellisle and colleagues reported that studies have failed to demonstrate a difference in TEE between nibbling and gorging individuals, and in turn no relationship has been found between habitual frequency of eating and obesity.[42] It has been suggested that any effects of meal pattern on the regulation of body weight are probably regulated through effects on the food intake side of the energy balance equation.

A reduction in total energy requirements (defined as the combination of energy expenditure and the energy required for growth) and fat oxidation rates in industrialised populations may also be responsible for increased body weights and fat gain, such that habitual energy intake has exceeded TEE [the combination of basal metabolic rate (BMR), thermogenesis, and energy expenditure due to physical activity].[31] The studies on BMR (the main component of TEE) however, did not show variations among obese, post-obese and non-obese children when body composition was included in the statistical analysis.[31] Mafeis also reported that thermogenesis induced by the standardised meals was irregularly and only slightly lower in obese children when compared to non-obese children, while meal-induced thermogenesis was no different between the post-obese and non-obese children.[31] In an attempt to explain this, Maffeis commented on the possibility that diet composition may have affected the meal-induced thermogenesis, and this, in theory, would then favour energy storage.[31] The last possible explanation from this model may indicate that the variance in TEE lies in the energy expended due to physical activity.[31]

An alternative (and somewhat contradictory) proposal for the role of energy balance in the development of overweight and obesity in children is based on the hypothesised role of a high protein to fat intake ratio.[31] In toddlers and young children, overall protein intake has been found to be much higher than recommended.[31] Since protein consumption encourages the secretion of insulin-like growth factor-1 and insulin (both promoters of fat storage and the proliferation of mature adipocytes), it is possible that such a diet may promote the development of obesity.[31] Further studies are however still needed to validate this hypothesis.[31]

On review of the available literature, Maffeis also found fat intake to be directly proportional to an individual's level of adiposity.[31] A physiological demonstration of how a high-fat diet is associated with fat gain is that of early infancy.[31] At this stage the infant only consumes milk (where the fat content of the human milk is more than 50% of its total energy content) and in turn his fat mass is seen to quadruple in a mere 4 months.[31] Fatty foods have a higher energy density, are usually more palatable, and due to fats lower satiating power, an individual is less likely to self-compensate and adjust his/her subsequent intake after a high-fat meal.[31]

While data from the NHANES has shown the estimated energy intake for adolescents (aged 12 to 19 years) to have increased by 95 kcal/day since the early 1970s,[43] and on a larger scale, the US food supply (total food produced, less exports, plus imports) has been found to have provided 500 kcal/d per capita more in 2002, as compared to the 1970's,[22] estimates of daily energy intake in children living in industrialised countries have not been able to show comparative excess consumption amongst obese subjects.[31] This is a clear demonstration of the suspected underestimation of self-reported food intake, and the relative lack of accurate methods available for the estimation of food intake amongst obese individuals.[31] Maffeis emphasises that this is why it is essential to validate food intake reported by study populations before any valid study conclusions can be drawn.[31]

1.2.2.3 Physical activity

While there are many factors contributing to the etiology of obesity, the basic principle lies in the fact that people who ingest more calories than they expend are incapable of balancing their energy needs, and will consequently accumulate fat stores.[44]

Sedentary behaviour has been recognised as a significant predictor of weight gain in later life, although large longitudinal studies using accurate techniques for the measurement of physical activity have not been done,[31] and regular physical activity (habitual) has also been recognized as an important general component of a 'healthy' lifestyle.[45] This is based on the evident beneficial links between regular physical activity during childhood and adolescence specifically, and both physical and behavioral health outcomes.[46] A number of environmental and social reasons have been identified to explain the high incidence of sedentary lifestyles amongst children.

Andersen and colleagues reported that almost one quarter of US children watch four or more hours of television per day, and these children were found to have a greater BMI than children who watched less than two hours per day.[47] Amongst South African children, white children were found to watch significantly less television than black children.[48] Maffeis reported that low physical activity levels have in fact been directly linked with TV viewing, and inversely linked with time spent outdoors.[31] Increased television viewing has furthermore been associated with body fatness in children from various ethnic groups in a number of other studies,[49-53] and it was also shown to be associated with lower activity in girls, and shown to possibly decrease metabolic rates and influence dietary choices.[21] An inverse relationship was found between physical activity and triceps skinfold thickness in a study by Ku and colleagues,[54] as well as with percentage body fat in boys but not in girls in a study by Taylor and colleagues.[55] In the longitudinal study by Klesges and colleagues, an inverse relationship between physical activity and BMI was also found, and the strongest correlations were between high BMI and low levels of physical activity and cardiovascular fitness.[56]

In contrast to these findings, the study by Dwyer and colleagues showed no significant difference in the mean time spent watching television and playing video games between obese and non-obese children, although they did report a weak positive correlation between the time spent watching television or playing video games and BMI.[57] These results were supported by those of the National Heart, Lung and Blood Institute's Growth and Health Study of 9-year olds, where no associations between BMI or skinfold thicknesses and television viewing ('inactivity') were found.[51]

Based on the findings of these various studies, it can be concluded that BMI and overfatness are habitually, but not always, negatively associated with physical activity. The role of decreased energy expenditure in balancing energy needs and the development of obesity is possibly simply too small to be measured by current methods for assessing physical activity levels,[22] and hence the presence of these contradictory findings. Maffeis however went on to report that the fraction of TEE assigned to physical activity was found to be comparable between obese and non-obese children, in both the United States and Europe, and so these discrepancies may alternatively be explained by the higher energy cost of weight-bearing activities per unit of exercise due to the heavier body that obese subjects have to manoeuvre.[31]

The physiology of the actual skeletal muscle cells of obese children has a maximal oxidative capacity comparable to that of non-obese children, regardless of their degree of adiposity.[31] The metabolic activity of this skeletal muscle plays a major part in the control of fat balance, oxidising an appropriate amount of fat each day.[31] Regular physical activity encourages fat oxidation in the muscle in addition to promoting post-exercise oxygen consumption.[31] Adiposity then (in the presence of physical activity) is able to increase overall fat oxidation by increasing the availability of circulating free fatty acids (released by the increased number of fat cells), which in turn endorses substrate competition between free fatty acids and glucose in the muscle, giving preference to a state of insulin resistance.[31] This post-absorptive fat oxidation rate is thus directly proportional to fat mass in obese children and adolescents.[31]

Children's levels of physical activity are also specifically influenced by the availability of facilities and equipment access, as well as peer influences.[31] According to Crawford and colleagues,[21] African-American girls participate in less physical activity than African-American boys, and among Puerto Rican pre-pubertal children, obesity in girls was associated with less frequent moderate to vigorous activities, while obesity in boys was associated only with less frequent low to moderate activities. Maffeis also reported that children with physically active parents tended to be much more active than children whose parents were inactive, and that evidence exists to show that children who participate in regular physical activity have more structured food patterns than those who do not.[31] In the South African situation, white children have been found to be more active than black children, and they were also found to be more likely to take part in physical education classes at school.[48] Although vast transitions amongst the various groups within the South African population have occurred in recent years, Kruger and colleagues reported that inactivity is unequivocally positively associated with the development of obesity, completely independent of the degree of urbanization.[58]

1.2.2.4 Socio-economic status

The relationship between the socio-economic level of the family and the development of childhood obesity has shown rather inconclusive results. It is usually an indirect relationship, whereby socio-economic status (SES) dictates lifestyle behaviours that in turn result in the increased risk for childhood obesity. Socio-demographic factors such as low maternal education and low family income have been found to influence patterns of activity and inactivity (television viewing, video viewing, computer and video games).[21] In addition, McVeigh et al concluded that South African children in the highest socio-economic quartiles, those whose mothers had the highest educational levels, and those who came from dual parent homes, were more physically active, watched less television, weighed more and exhibited greater lean tissue contents than their peers from the lower socio-economic quartiles.[48] Several studies in the US have demonstrated similar effects of lifestyle behaviours on childhood obesity by depicting inverse relationships between obesity and variables of family income, education, or both, among white adults, and particularly among females.[21,57] Such associations were less consistent among young children, males, and non-white ethnic groups in the US, and increasingly present between overweight prevalence and family income for female and male white adolescents (based on data from NHANES III for individuals aged 6 to 24 years of age).[21]

It has also been proposed that the increased urbanisation of large sectors of the South African population may also be involved in the increased risk of becoming overweight or obese.[59] Cameron and colleagues stated however that urbanisation is only a cause of increased overweight and obesity amongst children when it is complemented by an upgrade in SES.[60] In adult black women, increased levels of obesity have been with urbanisation, regardless of changes in SES.[59]

As an extension of this variable of urbanisation, rearing area was found to demonstrate a much stronger influence on the risk of overweight in young adulthood than both parental education and occupation,[31] and the risk for overweight was increased for individuals reared in areas with poor dwellings quality when compared with individuals reared in better areas.[31] This association was evident even when the effect of parents' education and occupation was controlled for.[31] Findings from the Transition and Health during Urbanisation of South Africans (THUSA) study amongst children (referred to as 'bana') showed that the prevalence of overweight and obesity amongst these children of 10 – 15 years of age, was greater in smaller households, and a significant association between percentage body fat and the number of members in a household was found specifically amongst boys.[61] The link between the increased risk for overweight and obesity in poorer areas might also be influenced to some extent by the previously mentioned association between children's levels of physical activity and the availability of and accessibility to appropriate facilities and equipment.

1.2.2.5 Race

Once differences in SES were controlled for, African-American youth in the NHANES-III still showed significantly higher mean BMI measures than did the white youth.[21] According to the findings of the Child and Adolescent Trial for Cardiovascular Health Study (CATCH), which followed an ethnically diverse group of more than 5 000 students aged 9 years at enrolment, the black race was a strong predictor of overweight at 11 years of age.[21] Baskin and colleagues, as quoted by Crawford and colleagues, commented that while little is understood about the mechanisms behind racial differences, African-American youth have been found to have lower metabolic rates.[21] Whether these differences are the results of genetic or environmental factors is however unknown.

In the South African Health of the Nation study, post-hoc analysis of BMI measures only found ethnically significant differences between 13-year old coloured and white boys.[62] Furthermore, the combined percentage of obese and overweight black females in the sample increased from 11.9% at 6 years of age to 21.8% at 13 years of age, while this combined percentage decreased from 25.4% at 6 years of age to 14.5% at 13 years of age amongst the white females in the sample.[26] Mvo and colleagues attempted to explain these racial variances using the observation that being overweight within the African culture is often associated with positive connotations of wealth and happiness,[63] while Clarke and colleagues suggested that being overweight within the African culture is often used as a form of proof that the individual is not affected by the human immunodeficiency virus (HIV) and consequently acquired immune deficiency syndrome (AIDS).[64] Armstrong and colleagues suggested that the white females may be more greatly influenced by the Western ideals of beauty and thinness.[26]

According to Crawford and colleagues,[21] the recent increases in the prevalence of overweight and obesity among American children specifically, are not limited to one age, gender, or ethnic group, and this suggests that the distinctive behaviours of the various ethnic subgroups of the American population are unlikely to be the major contributing factors. With the rising global epidemic of overweight and obesity, it then seems feasible that the major global contributors need to primarily be identified so that culturally and ethnically elements can appropriately be targeted.

1.2.2.6 Child rearing and the home environment

Factors related to child rearing may impact the development of childhood obesity.[21] According to a number of studies discussed by Crawford and colleagues,[21] breastfeeding was found to possibly protect against obesity, while a review of related literature by Maffeis concluded that breastfeeding (which for a number of other reasons plays a beneficial role in the infant's first months of life) was not proven to have a protective effect on the development of obesity later in life.[31] Recently however, two independent literature searches were conducted at the WHO in Switzerland, and at the University of Pelotas in Brazil, resulting in the publication of a consensus document of systematic reviews and meta-analyses by the WHO in 2007 regarding evidence on the long-term effects of breastfeeding.[65] Based on the meta-analyses of 33 mainly cohort or cross-sectional studies, the evidence suggests that breastfeeding may have a small protective effect on the prevalence of obesity.[65] In people who had ever been breastfed, the risk of becoming overweight or obese as adults was less than those who had never been breastfed (odds ratio 0.78 and 95 % confidence interval 0.72 to 0.84).[65] Although some publication bias was observed at times, larger studies (≥ 1500 participants) still demonstrated the protective effect of breastfeeding against obesity, suggesting that this association was not apparent as the result of publication bias.[65] Furthermore, when studies controlled for SES and parental anthropometry, the outcomes still showed a statistically significant protective effect of breastfeeding, making confounding bias also a less likely reason for the observed association.[65,66] Ip and colleagues [67] of the Agency for Healthcare Research and Quality in the US, also issued a report on breastfeeding and maternal and infant outcomes in 2007. Based on two meta-analyses of 9 and 17 cohort studies or cross sectional studies and one systematic review using meta-regression of 28 cohort or cross-sectional studies, they drew similar conclusions, stating that a reduced risk of obesity in adolescence or as an adult was observed in ever breastfed individuals as compared to never breastfed individuals (odds ratio 0.76, 95 % confidence interval 0.67 to 0.86 and odds ratio 0.93, 95 % confidence interval 0.88 to 0.99 respectively).[67] In clinical practice, the WHO now recommends exclusive breastfeeding (breast milk only, with no water, other fluids, or solids) for six months, with supplemental breastfeeding continuing for two years and beyond.[65]

Using data from the National Survey of Youth, Strauss and Knight found that psychosocial aspects of the home environment may also increase the risk for obesity, such that an association was found between home environments that scored poorly on cognitive stimulation and the presence of obesity.[68] They did however emphasise that these findings were not unambiguous and do still call for further investigations. Olvera-Ezzell and colleagues found that mothers with more years of education were more likely to provide their children with healthier foods, and that cultural perception of desired body size were found to determine child-rearing practices to some degree.[69] Furthermore, Maffeis reported that parental neglect during childhood was associated with the development obesity in young adulthood, independent of childhood BMI and age, gender and social background.[31]

Family lifestyle and food habits also play a role in shaping children's food preferences since children's eating habits are constantly modified by the opinions and behaviours of their parents, siblings, peers or relatives who may live with them.[31] Parent's adiposity and fat intake are in many ways linked to their children's adiposity and fat intake (i.e. familial similarities in food intake), emphasising a partial explanation for familial patterns of obesity.[31] TV viewing, with the bombardment of advertisements for food products, and parallel provision of messages about eating, also has some effect on the food choices of children, but this effect must always be seen within the family context as the parents or caregivers are essentially accountable for the foods that are made available and accessible in the home environment.[31]

Wilkin has drawn some interesting conclusion from the analysis of the relationships in BMI between parents and children from the EarlyBird study cohort.[70] The BMI's of daughters of obese mothers were found to be 1.39 standard deviations (SD's) greater than the BMI's of daughters of normal weight mothers, while the sons of obese fathers were found to be 1.20 SD's greater than the BMI's of sons of normal weight fathers.[70] Daughters of normal weight mothers and sons of normal weight fathers were in fact not found to be heavier than the reference child from 25 years ago.[70] Wilkin thus suggests that this same-sex diffusion of overweight and obesity is more likely to be of behavioural origin and not genetic.[70]

1.2.2.7 Genetic mechanisms

The behavioural origin of the same-sex transmission of overweight and obesity is however still only a hypothesis. Evidence from a systematic review of risk factors for obesity and two birth cohort studies published in 1997 (one by Whitaker and colleagues,[71] and another by Lake and colleagues [72]), showed that 79 % of 10-14 year old children with at least one obese parent were obese, independent of a genetic or environmental origin of the parental obesity.[18] In particular, identical twins of obese parents were seen to be more prone to becoming obese than those of non-obese parents.[31] This suggests a genetic element of obesity causation.[31] Studies in adopted children showed that they had greater similarity in adulthood BMI with their biological parents than with their adopting parents.[31] BMI inheritance has thus been proposed to be accountable for 25 % to 40 % of the inter-individual inconsistencies.[31]

Genes involved in weight gain do not directly cause obesity, but instead tend to increase the individual's vulnerability to fat gain when exposed to particular high risk environments.[31] Some examples of genes that have been recognised as playing a role in the development of obesity include the genetic defect of severe leptin deficiency which has been identified in two significantly obese children,[31] and a newly discovered anorectic peptide (cocaine and amphetamine regulated transcript (CART)).[31] CART is regulated by leptin and acts as a satiety signal in the hypothalamus.[31] In addition to this it interacts with the neuropeptide Y (NPY) and other hypothalamic regulators of ingestion processes.[31] Mutations of the pro-hormone convertase 1 (PC_1) gene are yet another identified set of defects which have been found to be responsible for the activation of pro-insulin processing.[31] These mutations have recently been reported in humans, and are now known to promote an autosomal recessive syndrome in women.[31] This syndrome is characterised by an early onset of obesity, amenorrhoea, post-absorptive hypoglycaemia, fatigue, an absolute deficiency of insulin and excessively elevated pro-insulin circulating levels.[31] The precise mechanism by which this defect actually causes obesity is still unknown. Mutation (Pro115GIn) of the peroxisome-proliferator-activated receptor γ2 (PPARγ2) gene promotes a decreased inactivation of PPARγ2 with an enhanced differentiation of pre-adipocytes, consequently promoting obesity.[31] Lastly, other transcription proteins, such as CCAAT-enhancer-binding protein alpha, which are activated in adipogenesis, have been found to increase the expression of PPARγ2, which induces fatty acid synthesis.[31]

Although linkage studies have indeed identified these numerous chromosomes as being related to the obesity phenotype, the complexity of the aetiology of obesity renders a single versus multiple gene defect is highly improbable.[31]

1.2.2.8 Adaptive mechanisms

Environmental factors may be mediated through adaptive mechanisms that contribute to increased risk for obesity in present or future generations. According to the thrifty gene theory, certain populations that have migrated to affluent industrialised societies are predisposed to obesity because harsh conditions, such as famine, experienced by previous generations resulted in genetic selection for populations with highly efficient (thrifty) metabolisms, and therefore, low metabolic rates.[21] The thrifty phenotype hypothesis suggests that the insulin-producing cells of the pancreas and insulin-sensitive tissues in the body adapt in response to poor nutrition during foetal and infant life, resulting in decreased growth in early life at the cost of increased risk for obesity and type 2 diabetes in later childhood and adulthood.[21] The increased tendency towards overweight and obesity with increased urbanisation is based on the principle of increased energy intake in the short term, while this hypothesis refers to a chronic change in exposures with genetic adaptation for survival.

Maternal factors have been found to be associated with obesity.[21] According to a study by Stettler and colleagues, maternal pre-pregnancy BMI was a positive and proportional forecaster of the adiposity of adult offspring (the group of offspring were followed up from birth until early adulthood), although it is still unclear though whether this relationship was caused by the home environment or genetics.[73] During pregnancy the foetus interacts with the mother and her metabolism, and this can be considered to be the first physiological contact that the child has with the environment.[31] During this time the hypothalamic centres of hunger and satiety are distinguished and an increase in adipose tissue occurs specifically during the third trimester.[31] Undernutrition during the first and second trimesters of pregnancy was found to be associated with a greater occurrence of obesity in the adults at the age of 19, while undernutrition during the last trimester of pregnancy was not associated with any consequent obesity.[31] This study was based on the assessments of young adult males born to pregnant women during the Second World War.[31]

It has also been speculated that a hyperglycaemic environment during gestation may cause the foetus to adapt to the excess fuels and nutrients in a way that may mediate the development of obesity.[21] This association has been identified in Native-American Youth born to type 2 diabetic mothers.[21] Maffeis added in agreement that children born to mothers who had diabetes during pregnancy (gestational or type 2 diabetes) were more frequently obese, independent of other factors, when compared to children of mothers who were not diabetic during pregnancy.[31]

Interestingly, fat mass has been found to vary physiologically between seasons.[31] Climatic and geographical elements in the development of obesity in children have thus been suggested.[31] Although data on this topic is limited and explanations for these findings are still being investigated, the available data proposes that the prevalence of childhood obesity is greater in the east and south of Europe than in the west and north of the continent.[31]

1.2.3 Development of Childhood Obesity and its Longitudinal Tracking into Adulthood

It has been suggested that the three stages of growth may be the key in the development of 'persistent obesity' that subsequently has bearing on the development of co-morbidities in adulthood. These stages refer to the prenatal period, the period of adiposity rebound (between the ages of 4 to 8 years) and adolescence [17,74,75] (i.e. the period of adverse visceral fat accumulation, and the time when an early adiposity rebound may be triggered by hyperplastic obesity).[74]

The CATCH study showed that a significant percentage of the children enrolled became overweight (7%) over the course of the study or remained overweight (25%). They also showed that only 5% of children who were overweight at the start of the study reached normal status over the course of the study.[57] These findings support the suggestions that the prediction of future obesity begins as early as 6-9 years of age.[57] In fact the atherosclerotic process also begins during childhood, concluding with the onset of vascular plaque in the third and fourth decades of life.[76] Furthermore, findings from the CATCH Study demonstrated that the changes in cardiovascular risk factors were most evident in children whose BMI or fatness was greater at baseline or who had become heavier or fatter during the study.[57] On the other hand, those whose comparative weight and adiposity decreased between the third and fifth grades, presented with far more favourable risk factor profiles.[57] This was supported by Dwyer and colleagues, who also concluded that the greatest risk for childhood obesity persisting into adulthood occurs among overweight adolescents,[57] and that the most dominant determinant of overweight and adiposity is a child's baseline status.[75]

Freedman and colleagues however, stated that more data is still needed to accurately assess the relationship between childhood weight status and the specific age of obesity onset, and morbidity due to coronary heart disease (CHD).[74] They stated that the uncertainty of the role of obesity onset in the development of adult disease remains because few studies have assessed weight status in both childhood and adulthood, and most of the studies that have shown childhood obesity to be prognostic of adult morbidity, have actually directed their investigations on populations where obesity was already present rather than on incident obesity in these populations.[74] The lack of information on obesity-related morbidities has then also compounded this problem.[74] Studies that do in fact have information on longitudinal tracking of BMI levels in both childhood and adulthood were reviewed, and the results were found to be contradictory.

The Harvard Growth Study found that obese adolescent boys (and not girls) were at increased risk for CHD mortality (independent of adult BMI),[74] while others concluded that the effects of childhood obesity were controlled by adult weight status. Some also suggested that the risk may be greatest among normal-weight children who become obese adults.[74] When using a measure of body fatness that was independent of build, Wright and colleagues concluded that little longitudinal tracking from childhood overweight to adulthood obesity was apparent.[77] The lack of any association between BMI at age 9 and percentage body fat at age 50, suggested that associations found between childhood and adult BMI may have mainly been reflective of the tracking of build rather than fatness, since body frame and lean muscle mass also contribute to BMI.[77] Children who were obese at 13 years of age showed increased risk for adulthood obesity, while the thinnest children showed the greatest adult risk at every level of obesity in adulthood.[77] The data used by this study however was based on a relatively small number of participants at both the childhood and adult periods, and so the conclusions drawn have only been based on well validated proxy markers for morbidity and not on actual outcomes.[77]

The two largest studies investigating the associations between childhood overweight and adult risk (the studies by Hoffman and colleagues published in 1988 and Allebeck and colleagues published in 1992) concluded that increased CHD risk was only found in the fattest 1-2 % of the subjects investigated.[77-79] Both studies also found higher mortality in the thinnest 1-5 %, and excess deaths as a result of either overweight or underweight, each represented only 1-2 % of all premature deaths.[77] They were thus able to conclude that the strongest evidence for the longitudinal tracking of adult onset co-morbidities associated with childhood adiposity was present for those individuals that were obese in late adolescence rather than childhood.[77] These actual outcomes correspond with the findings of Wright and colleagues discussed earlier.

While the exact age of obesity onset in childhood associated with the greatest adulthood CHD risk profile still needs to be accurately defined, the use of the international cut-off points of BMI proposed by Cole and colleagues,[11] appears to be one of the best tools currently available for identifying youth with increased adulthood co-morbidity risk profiles. Whether our intervention decisions are based on the proposal that the cumulative lifetime risk of CHD is greatest among those who are persistently overweight from childhood to adulthood,[74] or the suggestion that normal weight adolescents who grow to be obese adults are at the greatest risk, or even the findings that only the obese (and not the overweight) adolescents will be at the greatest risk for adulthood co-morbidities, the monitoring and tracking of adiposity levels through BMI assessment is a practical and feasible epidemiological tool, that can provide us with some degree of latitude for successful intervention implementations.

1.2.4 Physical and Psychological Implications of Overweight and Obesity

Research from the University of California's (UCLA) Managed Care Center for Psychiatric Disorders showed that the health complications linked to obesity raises a person's health care costs by 36% and medication costs by 77%,[20] and while this combination of risk factors may predispose overweight young people to the development of non-communicable diseases (NCDs), these diseases were found to account for 37% of deaths among adults in South Africa in the year 2000.[25]

Fulton and colleagues reported on a review of six studies which showed that, independent of prospective confounding or mediating variables (variables such as adult weight status, cigarette smoking and socioeconomic status), obese children have approximately a 1.5-fold increase in risk for all-cause mortality and an approximate 2-fold increase in risk for CHD mortality.[80] Suha and colleagues reported that on studies which showed the increase in childhood obesity to be associated with an escalation in the incidence of type 2 diabetes by a factor of 10 (hence the new term 'diabesity').[81] Impaired glucose tolerance was found to be highly prevalent among children and adolescents with severe obesity, regardless of ethnic group.[80,82] The study on impaired glucose tolerance in obese children and adolescents, Sinha and colleagues found that insulin resistance, initially associated with hyperinsulinemia and hyperproinsulinemia, was the most important risk factor linked to the development of impaired glucose tolerance in severe childhood obesity, and that appropriate lifestyle changes were indeed able to delay or prevent the progression from impaired glucose tolerance to frank diabetes.[82] Crawford and colleagues also identified central adiposity or truncal fatness as an independent feature in the development of type 2 diabetes and cardiovascular disease.[21] Interestingly, Steyn and colleagues found greater central fat distributions in children stunted in early childhood.[24]

Childhood obesity has been directly linked to irregularities in blood pressure and lipid profiles, which when combined with abnormal glucose homeostasis, considerably increases the risk of coronary artery disease (specifically hypertension and dyslipidemia) in adulthood.[11,16,18,20,21,23,34,57,80] Odd ratios for these findings in obese children (as determined in 2001) were 4.5 for raised systolic blood pressure, 2.4 for raised diastolic blood pressure, 3.0 for raised low density lipoprotein (LDL) fraction of cholesterol, 3.4 for raised high density lipoprotein (HDL) fraction of cholesterol, , and 7.1 for raised triglycerides.[18] According to Dwyer and colleagues,[57] the associations of both excess weight and fatness with undesirable lipid profiles, include increased total and apo-B cholesterol and decreased

HDL. Many of these studies have assessed overweight as a measure of BMI, however even when predictive equations facilitated by the measurement of triceps and subscapular skinfold thicknesses were used (as in the Bogalusa study), significant associations between body fatness and the cardiovascular risk factors of elevated blood pressure, total cholesterol and serum lipid levels were found.[57]

In addition, childhood obesity increases the risk for breast and gastro-intestinal cancers [18,20] in adulthood, as well as for osteoarthritis,[18] orthopaedic conditions,[80] dermatological disorders, aggravation of rheumatic diseases,[18] asthma, sleep apnoea and other respiratory diseases,[18,80] gastroenterological conditions such as gallstone formation, and neurological conditions such as pseudo-tumour cerebri.[80]

Overweight and obesity also presents immediate psychosocial risks, such as distorted body image, social isolation and social rejection in childhood.[18,57,80] Evidence from experimental and longitudinal cohort studies have shown that overweight children often suffer from psychological problems, which are likely to persist into adulthood,[18] and the social burden of obesity has even been found to affect interpersonal relationships.[18] In Western populations it has actually been noted that children from as early as 6 years of age have understood the societal messages that overweight is undesirable.[18] Cognitive and emotional development are divided into early, middle and late adolescence, and it is in early adolescence that the adolescent is characteristically consumed with elements of body image.[83] Boutelle and colleagues reported that overweight adolescents use more unhealthy weight management strategies and often avoid employing healthier lifestyle strategies such as healthier eating habits and increased physical activity.[84] At this stage in their lives, the adolescents are willing to do whatever it takes to make them look better or improve their body image.[83] A longitudinal study by Gortmaker and colleagues in fact showed that women who had been overweight as adolescents completed fewer years of schooling, had higher rates of household poverty and had lower household incomes when compared with women who were not overweight as adolescents.[85]

1.3 MODIFIABLE RISK FACTORS

Knowledge of all the characteristics of children who become obese is a matter of public health importance, as it plays a dual role in identifying high-risk children and in objectively planning and implementing primary prevention strategies.[57] This having being said, and while taking the previously discussed possible causes of obesity into account, a typical South African scenario identified by Bt20 highlights a number of feasibly modifiable risk factors, some of which will be discussed in further detail: 'An adolescent living in Soweto uses public transport to school as her mother can't afford a bicycle and it's not safe or 'cool' to ride. She has R10 for lunch, which she spends on a sweetened beverage and a packet of potato chips. There are few sports facilities at school and physical education is not promoted, and consequently she doesn't participate in any school sport. At home she watches the afternoon 'soaps' and snacks on sandwiches. She strolls down the street to meet up with her friends, but engages in little other home-based physical activity. Her mother, who is obese and has high blood pressure, gets little exercise other than walking to and from the taxi rank and local grocery store. With her modest income she prepares a usual dinner – stiff maize-meal with fatty bones fried and made into gravy. After dinner she has her fourth cup of coffee for the day with 3 teaspoons of sugar and watches some television while doing her ironing'.[25]

1.3.1 Breakfast Consumption

An innate problem with evaluating breakfast studies is the way in which breakfast consumption is defined, particularly in terms of the frequency of consumption, the time of day at which breakfast is consumed, and the types of foods consumed for breakfast.[23] A wide range of definitions are used to conceptualise breakfast consumption in the various studies completed in this field, and it is important to acknowledge these variations when using the findings as a basis for population-based recommendations. Breakfast consumers may refer to individuals who consume breakfast every day, individuals who consume breakfast on every school day, individuals who consumed breakfast on the day of the dietary survey, individuals who consume breakfast on a minimum number of days per week, or individuals who routinely consume breakfast.[23]

Breakfast consumption by children and adolescents in the United States has decreased over time, such that between 1965 and 1991, breakfast consumption in children aged 8 to 10 years old, and adolescents decreased by 9% and 13 to 20%, respectively.[23] It was found that children and adolescents skipped breakfast more than any other meal, and 42% of 12 to 13 year old children reported that they did not eat breakfast every day.[23] Song and colleagues reported that in 2001, 6.5% of 4 to 8 year olds, 20.5% of 9 to 13 year olds, and 36.1% of 14 to 18 year olds were not consuming breakfast regularly.[86] In an ethnically diverse population of both urban and rural South African male and female pupils between the ages of 16 and 18 years, 21% of the black, 19% of the Indian, 13% of the European-African, 13% of the Malay and 14% of the white pupils, did not consume a solid breakfast on a daily basis.[87] Furthermore, in a review of relevant studies, 14-19% of South African children were found to eat nothing before going to school.[88-91] In the US skipping breakfast is typically more prevalent in girls, older children and adolescents,[23] and breakfast-skipping behaviour has been associated with other negative lifestyle factors such as smoking, irregular exercise, frequent alcohol use, behavioural disinhibition,[92] dieting, and concerns about body weight, while general reasons given by children for skipping breakfast include a lack of hunger, lack of time, or dieting in an attempt to lose weight.[23,93] It is thus evident that the benefits of breakfast consumption should be viewed as an area requiring much more attention when or before being advocated as a component of an overall preventative strategy aimed at reducing disease risk through the enhancement of child and adolescent health.[23,92]

Rampersaud and colleagues made a number of recommendations for breakfast habits in children and adolescents, promoting the consumption of a healthful breakfast at home or at school on a daily basis while not surpassing daily energy requirements; promoting the inclusion of foods from a variety of food groups including wholegrains, fruit and dairy,[23] in which case a high-fibre, low sugar, fortified Ready-to-Eat Cereal (RTEC) together with a fruit would be an ideal choice; and promoting the consumption of breakfast either at school or on their way to school if they are inclined to skip breakfast due to a lack of time, especially since many breakfast foods can be consumed while on the go [23] (this could again include dry RTEC's and fresh fruit).

1.3.1.1 The effects of breakfast consumption

Breakfast has in many instances been referred to as the most important meal of the day.[94] The scientific evidence supporting this claim in terms of the proven benefits of breakfast consumption will be discussed in further detail.

1.3.1.1.1 Energy and nutrient intake of breakfast eaters and breakfast skippers

Optimal nutrient intake is a fundamental prerequisite for meeting the nutritional demands of growth and development in childhood, and micronutrient intakes particularly may play an important role in the reduction of disease risk and deleterious health outcomes in childhood, adolescence and adulthood.[23] Milk was identified as one of the most frequently consumed foods by children at breakfast in the United States, Canada and Europe.[23] Breakfast cereals, which are normally consumed with milk, are popular in the United States, Canada, the United Kingdom, Spain and Croatia, while various types of bread are also commonly eaten.[23] Rampersaud and colleagues reported that the changes observed in breakfast consumption in the US over a 26-year period include an increased consumption of RTEC's, low-fat milk, and juices, and a decreased consumption of wholegrain breads, high-fat milk, and eggs.[23] Currently, amongst the adult South African population, the foods most commonly consumed on a daily basis have been identified as maize porridge (78%), white sugar (77%), tea (68%), brown bread (55%), white bread (28%), non-dairy creamer (25%), brick margarine (21%), and full cream milk (19%).[95] Amongst 6 to 9 year old children in South Africa, the most common food items consumed on a daily basis include maize porridge (72%), sugar (76%), tea (51%), full-cream milk (35%) and white bread (33%).[95] Of these dominant food choices in these two South African sub-groups, it is evident that RTEC's and juices are not common daily (and by extension breakfast) choices. In fact, South African children most commonly consume three of the above-mentioned items for breakfast i.e. maize-meal porridge, brown bread and tea.[88-91]

Eating breakfast has generally been associated with an total improvement in food choices (such as increased consumption of milk and vegetables, and decreased consumption of soft drinks and French fries) amongst children and adolescents in the US,[23] such that breakfast skippers have been found to be more likely to have diets defined as poor or inadequate.[23] Breakfast skipping has also been linked to with increased snacking, and particularly an increase in the intake of high-fat snacks.[23]

a) Energy and macronutrient intake

After a recent review of available literature and population-based survey data from the US, Rampersaud and colleagues stated that breakfast eaters appeared to have a higher total daily intake of energy compared with breakfast skippers, suggesting that the breakfast skippers did not consume more calories at the other mealtime in an attempt to compensate for the breakfast deficit.[23] This was particularly true amongst female adolescents.[23] Berkey and colleagues had similar findings in that children who reported that they never ate breakfast, maintained lower energy intakes than those who ate breakfast on a daily basis.[93] Breakfast eaters were more likely to have higher daily intakes of total carbohydrate, protein, fat, and saturated fat, while daily fat intakes (expressed as the percentage of the total daily energy consumed) were lower amongst breakfast consumers in some, but not all studies reviewed.[93] Higher energy breakfasts (those contributing more than 25% of the daily energy allowance) were associated with a higher mean daily intake of carbohydrates and a lower intake of fats (again expressed as a percentage of total energy intake) when compared with lower energy breakfasts (those contributing less than 15% of the daily energy allowance).[23] Specifically amongst preschool children, when a breakfast with more than 50% of its energy from carbohydrates was consumed, the whole-diet fat content tended to be lower than when a breakfast with less than 50% of its energy was supplied by carbohydrate.[23] Furthermore, breakfasts with a higher fat intake (> 35% of energy) were associated with higher total and saturated fat intakes throughout the day.[23] Compared with children and adolescents consuming lower amounts of RTECs or with non-consumers, RTEC consumers specifically, had higher whole-day intakes of carbohydrates, refined grains and sugars (expressed as a percentage of the total daily energy intake).[75] Fibre intake was also found to be significantly higher in breakfast eaters when compared with breakfast skippers.[23,96,97]

When South African rural black and urban white children were compared, 0% of the black children investigated consumed a cooked breakfast, while 30% of the white children investigated consumed such a breakfast.[89] The cooked breakfasts were seen to offer twice the number of kilojoules of the porridge or bread breakfasts, and two to three times more fat.[89]

b) Micronutrient intake

Breakfast eaters have higher daily intakes of micronutrients and are more inclined to meet their nutrient intake recommendations when compared to those who skip breakfast.[23] Nutrients that seem predominantly affected across a variety of population groups include vitamins A and C, riboflavin, zinc, iron and calcium,[23] while iron, B vitamins and zinc intakes are improved with the inclusion of RTEC in the diet.[98]

Mean daily intakes of calcium were found to be higher in breakfast eaters when compared to breakfast skippers, and this subsequently forms part of a key nutritional issue amongst children and adolescents since peak bone calcium accretion occurs during adolescence.[23] Daily calcium intake was found to be particularly higher in RTEC consumers, and this can possibly be explained by the fact that RTEC is normally consumed with milk (a good source of calcium itself).[98] This however has not been observed in all studies,[99-101] and Rampersaud and colleagues in fact reported that a significant number of children (in particular female adolescents) did not meet the adequate intake (AI) recommendations for calcium.[23] In adolescents the reference intake for calcium in South Africa is 1 300 mg, and so a recommended milk intake of two cups (400-500 ml) will cover approximately 50-60% of the adolescents' daily calcium requirement.[102] This is a realistic recommendation for intake considering the milk can be used over porridges and breakfast cereals, with tea or coffee, and even as a solitary drink.[102]

The intake of micronutrients amongst South African children is inadequate,[103] and since breakfast contributes a significant portion of a child's overall nutrient intake, it has been suggested that breakfast skippers are more likely to present with micronutrient deficiencies.[104]

1.3.1.1.2 Effects on body weight

The relationship between breakfast consumption and body weight is not well established, and after compiling a review of current literature, Rampersaud and colleagues stated that to their knowledge there have been no randomized controlled trials to investigate breakfast consumption and weight control in children and adolescents.[23] Such an investigation may thus provide some clarity on the application of the available study findings, which are on many occasions contradictory. They also commented that the differences in current study results may possibly be the result of statistical methods implored, as only four of the eight studies reviewed controlled for the various combinations of confounding factors such as age, grade in school, race, and parental SES). Of these four, three were able to report on significant associations between body weight and breakfast consumption.[23] Furthermore they suggested that result variances may be due to underreporting by overweight children and adolescents, associations between breakfast skipping and lower levels of physical activity affecting energy balance, and the use of breakfast skipping as a dieting strategy amongst adolescents who consider themselves to be overweight.[23]

The possible role of breakfast consumption in the maintenance of normal weight status in children and adolescents has however been identified.[23] An association has been found between body weight and RTEC consumption specifically, such that higher intakes were associated with lower BMI's (even after adjustment for gender, age, socio-economic status, and race).[98] While this association could not be explained in terms of energy intake (which as previously mentioned is often higher in RTEC consumers versus non-consumers or those consuming lower amounts of RTEC), it may be linked to the fact that breakfast consumers tend to make healthier food choices and participate in higher levels of physical activity.[98] It is also possible that individuals who eat breakfast regularly have lower intakes of calories from fat, and this is particularly relevant amongst individuals whose breakfast includes a RTEC.[105] It may also be that breakfast eating is associated with increased eating frequency, which in turn promotes less competent energy utilisation, increasing dietary induced thermogenesis.[106] Yet another plausible explanation is that overweight children or adolescents tend to underreport their dietary intake compared to their normal-weight peers.[23]

A number of cross-sectional studies showed positive associations between BMI's or weights of children and adolescents and the act of skipping breakfast.[107-111] One large cross-sectional study (sample size of more than 24 000 subjects) reported that a one-unit increase in BMI was found when breakfast consumption decreased in adolescents between the ages of 11 and 18 years.[112] The study by Boutelle and colleagues showed that usual breakfast consumption (defined as breakfast consumed on school days only) was associated with 30% lower odds of being overweight or obese in boys and of being obese in girls.[84] Furthermore they found that overweight and obese children and adolescents were more prone to skip breakfast than their normal or underweight peers, especially amongst the female subjects investigated.[84] Thus, the energy intakes of normal and underweight persons are more likely to be evenly distributed throughout the day than that of the obese person skipping breakfast.[113] A study by Keim and colleagues actually showed that moderately obese women lost more weight when they consumed 70% of their daily energy intake before noon instead of in the afternoon or evening.[114]

In a longitudinal study by Berkey and colleagues, using the data from the Growing Up Today Study (GUTS), overweight children who skipped breakfast lost BMI over time as compared with overweight children who consumed breakfast on 5 to 7 days in the week.[93] On the other hand, the BMI's of normal weight children who skipped breakfast were found to increase (albeit not significantly) when compared with normal weight breakfast eaters.[93] The reason that normal and overweight children would respond differently to breakfast skipping is unclear, but it has been proposed that differences in resting energy expenditure (REE) may be a possible explanation.[93]

Some of these findings have identified breakfast skipping as a strategy that could indeed be used for the promotion of weight loss amongst overweight children, adolescents and adults,[115] however it is imperative to encourage the use of alternative methods of energy reduction in light of the numerous other health advantages that have been associated with breakfast consumption. Breakfast eating is in fact a behaviour that is often targeted in weight management programs and its correct integration into one's daily consumption regimen has been found to contribute to long-term weight-loss maintenance.[116] This is potentially explained by the suggestions that these breakfast eaters may tend to choose less-dense energy foods during the remainder of the day, that the nutrients consumed at breakfast may leave the subject with an improved capacity for performing physical activity, or as previously mentioned, the fact that regular breakfast consumption tends to be a marker for a lower-calorie, lower-fat eating style.[116]

1.3.1.1.3 Physiological effects

Associations between breakfast consumption and serum lipids have been inconsistent. On review of the literature, it was found that children and adolescents who skipped breakfast had lower total cholesterol intakes when compared with breakfast eaters, however, mean plasma cholesterol concentrations were significantly higher in school children (aged between 9 and 19 years) who skipped breakfast when compared with children eating breakfast.[23] Similarly, adults who skipped breakfast were found to have higher serum cholesterol levels than those consuming breakfast.[23]

1.3.1.1.4 Cognitive, academic, psychosocial and behavioural effects

Breakfast may biologically affect brain function and cognitive test performance by altering the short term metabolic responses to those of fasting conditions so as to maintain a supply of nutrients to the central nervous system, or through the long-term effects on nutrient intake and nutritional status,[23,117] or even by improving blood glucose concentrations.[23] In other words, breakfast consumption can impact cognitive and academic performance, psychosocial functioning, and school attendance by merely abolishing the presence hunger.[23] It is hypothesised that the brain function of children is especially influenced by the metabolic stresses of fasting (where an overnight fast leads to gradual decreases in blood glucose and insulin concentrations, in addition to changes in neurotransmitters and metabolic agents which have multiple effects on cognitive functioning), since their cognitive processes are at critical stages of maturing.[117]

Short-term experimental studies have provided some support for the positive effects of breakfast on areas of memory, and although current data is less supportive for the general effects of breakfast consumption on cognitive variables such as problem solving, attention, listening comprehension and reading,[23] breakfast omission has indeed been linked to reduced speed and accuracy on tests of visual and auditory short-term memory, recognition memory, spatial memory, delayed recall, and immediate recall, in children and young adults.[118-123] Berkey and colleagues also found that the frequency of breakfast consumption was positively correlated with self-reported quality of schoolwork.[93] Within the South African context, school breakfasts were found to have a positive effect on the cognitive and behavioural performances of undernourished grade 2 and 3 children from a farm school outside of Johannesburg.[124] In addition, improved vitamin A, iron and iodine statuses amongst a group of South African school children lead to significantly improved short-term memory and attention span.[125]

It is possible that one of the long-term benefits of breakfast consumption in children is linked to the fact that a decrease in cerebral iron from a diet that is deficient in iron could compound the stress associated with an overnight fast.[117] Two observational studies, using the Paediatric Symptom Checklist, showed that psychosocial function improved considerably in participants whose nutritional status improved with a school breakfast, or in those who exhibited increased participation in the breakfast program.[23] Two randomized controlled trials showed positive effects of a school breakfast on achievement scores and school attendance rates in rural Jamaican children, and the results of these two controlled trials have been verified by observational studies which steadily showed a beneficial effect of breakfast consumption on academic and achievement test scores, tardiness rates, and school grades.[119] Most noteworthy was the fact that participation in these school breakfast programs was found to significantly increase school attendance.[117] This factor alone could then be indirectly responsible for the improved long-term psychosocial and academic functioning of the children, by facilitating prolonged and more frequent exposure to the social learning environment. It is important however to account for SES variables such as family income and parental education when drawing associations between cognitive and academic performance and breakfast consumption, since both these variables are themselves independently also predictive of academic achievements in children.[23]

Improvements in measures of depression and hyperactivity were also noted in children with increased school breakfast program participation, and breakfast was reported to have a positive effect on components of mood, contentment and alertness, while no significant effect on feelings of tranquillity or anxiety was found.[23]

1.3.1.2 Ready-To-Eat breakfast cereals

A quarter to a half of children between the ages of 4 and 18 years regularly consume cereal for breakfast.[86] When non-children's cereals were compared with children's cereals, the non-children's cereals presented with higher energy, energy from fat, carbohydrates, fibre, protein and sodium than the children's cereals (per recommended serving), and the children's cereals were significantly higher in energy (8% more), carbohydrate, sugar (52% more), and sodium (15% more) when compared to non-children's cereals per actual gram of cereal.[94] Using the 2005 Dietary Guidelines for Americans, the mean proportion of daily limits on added sugars consumed in one serving of children's cereal ranged from 11% of the daily limit for active boys between the ages of 14 and 18 years to 92% for sedentary girls between the ages of 9 and 13 years.[94] On the whole, 60% of the children's cereals investigated fell short of meeting the guideline for sugar of no more than 35% of the cereal weight.[94] The important role that all food and nutrition professionals thus have in advocating only those RTE children's cereals for which there are scientifically supported benefits is quite clear.

The benefits of RTEC as a desirable breakfast option (and more so where weight management is involved) are similar to the benefits of eating breakfast in general, but can be summarized as three main areas of more specific benefit. Firstly, even though cereals provide energy, they are also commonly low in fat and high in carbohydrate, and provide a significant amount of insoluble fiber.[32] Secondly, even though RTEC consumers can be found to present with greater carbohydrate intakes,[75] the wealth of recent information on the benefits of low glycemic index (GI) diets has identified a potential role for low GI RTEC's in the management of overweight and obesity.[126] This theory was used as the basis for a study by Ludwig and colleagues, where obese children were fed high-, intermediate- and low-GI breakfasts and lunches of equal energy content.[127] The children were then allowed to have a voluntary food intake for the rest of the day. The results indicated that the voluntary intake was 53 % higher in children after the consumption of the high-GI breakfast.[127] Lastly, Cho and colleagues suggested that an organized meal style is typified in RTEC consumption at breakfast time, since the meal is typically eaten at home, it is not normally (although it can be) consumed 'on-the-run', and that it is this element of 'an organized breakfast' that is possibly most closely associated with appropriate body mass regulation.[128]

1.3.1.2.1 The Glycemic Index (GI) of composite breakfast meals

During the past two decades a large number of studies have discussed the use of GI in different population groups, including the obese, diabetics, and those individuals with cardiovascular disease.[129] According to Pollitt and Matthews,[117] it is biologically conceivable that the amalgamation of biochemical changes occurring with the duration of a fast, as well as the timing, size and composition of a particular breakfast meal may function concurrently to determine the degree to which cognition is affected by breakfast consumption as opposed to its omission. The study by Gold also supports the principle that cognitive efficiency may be improved by the rate at which blood glucose concentrations return to their baseline levels.[130] This rate is usually influenced by factors that affect glucose regulation and utilisation, and it seems a particularly viable conclusion considering glucose is the primary substrate used by the brain for cognitive activity.[130-131]

The suggestion that a low GI diet may have a role in reducing caloric intake and consequently in the management of obesity, and long-term weight control was briefly mentioned as one of the benefits of regular RTEC consumption. Adding to this other studies have suggested that a low GI diet may possess the ability to increase the satiety value of food [126,132] and possibly promote weight management by promoting fat oxidation at the expense of carbohydrate oxidation.[126] One such study by Warren and colleagues had similar findings to that of Ludwig and colleagues,[127] and showed that the type of breakfast consumed had a significant effect on the mean energy intake at lunchtime, such that lunch intake was lower after a low-GI and low-GI with added sucrose breakfast versus lunch intake after high-GI habitual breakfasts.[126] A study by Ball and colleagues investigated whether a low-GI meal replacement produced different metabolic, hormonal and satiety responses in overweight adolescents to a low-GI whole-food meal, when compared with a moderately high-GI meal replacement.[132] Different insulin responses occurred between the two meal replacements, and satiety was prolonged after ingestion of the low-GI meal replacement.[132]

Concerns about the clinical relevance and practicality of the GI include the validity of GI in mixed meals if calculated from the weighted GI values of the single ingredients (as recommended by the WHO and Food and Agricultural Organisation (FAO) guidelines of 1998).[129] This concern is noteworthy considering individuals do not usually eat single foods but combine them in mixed meals. Flint and colleagues concluded that it was not possible to predict GI in composite breakfast meals using values from international GI tables, and emphasise the importance of incorporating the total energy, fat and protein content of a meal to predict its GI.[129] The use of the Glycemic Load (GL) of mixed meals is thus one step closer to functionally (and more accurately) predicting the blood glucose rise for a meal based on several foods with different GI values, since it takes both the type and amount of carbohydrate in the meal into account.

1.3.2 Snacking

In a study by Cross and colleagues, children were identified as the highest group of snackers, and the afternoon was marked as being the most common time for snacking.[133] Some eating episodes of snacking may be set off by the presentation of foods with strong sensory appeals, even if the episode is not preceded by any kind of change in blood glucose concentrations.[134] A spontaneous drop in blood glucose concentrations is however always followed by a search for and consumption of food.[135] This is most likely due to the ability of a drop in blood glucose to trigger the central glucoreceptive elements of the body in response to the detected shortage in immediately available glucose.[136]

According to Bernstein,[137] in free-living humans, the intervals between meals depend on a combination of the energy intake at the preceding meal and the rate of nutrient utilization. After an eating episode, the period before the available levels of glucose decrease will depend on the rate of utilization of available carbohydrates, and then at any time during the inter-meal interval, the amount of accessible carbohydrate will be a merged function of the carbohydrate content of the previous meal, the extra glucose provided by gluconeogenesis, and the amount of glucose spared by fat oxidation.[136] It has in fact been shown experimentally that when a meal is triggered by hunger sensations, the fatty acid concentrations are rising and the blood glucose and insulin concentrations are low.[138] When a snack was consumed in a state of satiety, Marmonier and colleagues did not find any significant difference in the latency of the dinner request and the energy intake at dinner.[136] Instead the consumption in the state of satiety favoured storage since in the presence of increased insulin secretions, and unchanged (insignificantly changed) blood glucose profiles.

Snacking is currently an important component of the American diet as can be quantified by the percent of snacks consumed outside of the home and the general snacking occasions per day.[139] Nicklas and colleagues reported that nearly all US children aged 1 to 19 years snacked once per day and 36 % snacked four or more times per day.[140] Jahns and colleagues reviewed the data on subjects aged 2 to 18 years from three nationally representative surveys of the US population, and found that when comparing snacking activity between the genders slightly more boys than girls were found to snack.[139] They also found that the greatest proportion of snacking was found at the higher income and education levels.[139] When the USDA's nationally representative surveys from 1977-1978 to 1994-1996 were reviewed, the age group of 12 to 29 year olds showed the largest increase in the number of snacks per day, from 1.7 snacks to 1.92 snacks per day,[141] and the 12 to 18 year old subjects in every period examined (form 1977 through to 1996) were shown to gain the highest quantity of calories from snacks.[139] Regardless of age, the snacks consumed were also found to be more energy dense than meals.[139] Snackers were found to have greater intakes of carbohydrates, fat and saturated fat than non-snackers, and the total energy intake from snacks (as a proportion of the total daily energy intake) increased from 20% in 1977-1978 to 23% in 1994-1996.[141] From these reviews it was concluded that the increase in nutrient contribution of snacking is largely caused by an increase in the occurrence of snacking and not by an increase in the actual size of the snack (which in fact remained constant in during the period examined).[139] Recent reports by Young and colleagues in 2002 have however discussed an increase in commercially available food portion sizes and so this may currently be presumed to be an additional contributing factor to the greater nutrient contributions of snacks.[22] The reviews also indicated an increase in the energy density of snacks during the period examined (approximately 14 to 20 kcal/g more),[139] and it has even been suggested that this increased energy density of snacks is associated with less satiety per gram of food intake, and subsequent passive overconsumption.[139] With these statistics in mind, there is evidently a huge demand on the food industry for the development of less energy dense and more healthful snacks.

Lawton and colleagues, exposed 36 normal-weight habitual snackers to four different snack types (high fat and non-sweet; high fat and sweet; low fat and non-sweet; and low fat and sweet) for three weeks each.[142] Consumption of the high fat snacks increased the percentage of total daily energy intake from fat from 37 to 41 %, while consumption of the low fat snacks (both sweet and non-sweet) decreased the total daily energy intake from fat to 33.5 %.[142] This in turn suggests that in habitual snackers, generous consumption of low fat snacks (when compared with high fat snacks) is an effective strategy to decrease fat intake and meet the recommendations of dietary guidelines without increasing total daily energy intake.[142]

It can thus be deduced that it is the type of snack specifically that subsequently determines whether the act of snacking has a positive or negative effect on the snackers' weight. Based on a Canadian report identifying the top three reasons for snacking (people liked the taste of snack foods, they consumed snacks to satisfy their hunger, and snack foods were considered to be convenient),[143] it is also just as important to maintain an aesthetic and gustatory appeal of the snack items when the development of more healthful snacks is attempted.

1.3.3 Physical activity

Health statistics released by the US CDC in 2000 indicated that 69% of children aged 12 to 13 years reported that they habitually partook in vigorous physical activity compared to 38% of children aged 18 to 21 years.[46] In 2006, Gidding and colleagues reported on findings from the Youth Risk Behavior Surveillance System (YRBSS), whereby a decrease in vigorous activity (determined as activity on three or more of the past seven days) from 69.5% in 1999 to 66.6% in 2003 was found amongst high school adolescents.[76]

Within the South African context, very little data is currently available on the national prevalence of physical activity, although two cross-sectional studies performed amongst urban black South Africans livings in the Western Cape, did provide some insight as to the level of necessity for related interventions. These studies revealed that no physical activity (neither during occupation nor during leisure time) was present amongst 30% of the men and 40% of the women, and a further 40-60% were found to be minimally-to-moderately active.[144] Furthermore, young women between the ages of 15 and 24 years were identified as a particularly vulnerable group within this population, showing the lowest levels of physical activity in the study.[145] Adding to this dire situation, statistics published in 2002 revealed that less than one-third of black South African children are actually taught physical education at school.[62]

On a larger scale, a review published in 2001 showed the population attributable risks (PAR) of physical inactivity for the various chronic diseases in Western society to be very high, with the PAR of physical inactivity for mortality from CHD and diabetes mellitus standing at 35% each.[45] In other words, 35% of deaths caused by cardiovascular disease and 35% of deaths caused by diabetes mellitus could have (in theory) been averted if everyone was vigorously active.[45] Findings from the National Demographic and Health Survey (DHS) performed in 1998 showed that the prevalence of risk factors for NCDs in South Africa was in fact similar to those in developed countries.[144] These NCDs have been documented to account for 28.5% of deaths of all South Africans between the ages of 35 and 64 years,[146] and more than 56% of all South Africans between the ages of 15 and 64 years presented with at least one modifiable risk factor for the development of a NCD of lifestyle.[146]

The only cardiovascular risk factors known to be influenced by physical activity in children and adolescents are body fatness and cardiopulmonary fitness.[45] While physical activity and dietary intake are highly associated, a decrease in body fatness is only accomplished when an increase in physical activity occurs together with a decrease in energy intake.[45] There is in fact some evidence that indicates that it is much easier to lose bodyweight by decreasing energy intake than by increasing physical activity levels.[45,75] The definitive physiological role of exercise in weight loss is not fully understood, but it is known that exercise appears to increase fat oxidation,[147] prevent the loss of lean body mass and subsequently prevent the associated decrease in metabolic rate.[148]

Based on current literature available, Twisk concluded that there is also only limited evidence to show a link between physical activity and inactivity during childhood and adolescence and physical activity and inactivity during adulthood.[45] Malina reported that the long term sustainability of inactivity is much higher than the sustainability of activity.[149] In light of this and the lack of vast scientific evidence on the exact effects of physical activity on the health of children and adolescents, it should nonetheless be noted that adequate physical activity certainly does encourage behaviors that sustain wellness (even if the long term stability is poor [149]), and undoubtedly plays a key role (even if not a direct role) in weight management.[150] Physical activity should thus unquestionably be promoted as a basic component of lifestyle, from as early as feasibly possible, in an attempt to integrate the physical activity into daily routine, and increase the long-term stability of such activity (at least as much as possible).

In 1998, the Health Education Authority symposium 'Young and Active?' proposed a set of international-based guidelines stating that all young people should partake in physical activity of at least moderate intensity for one hour per day, and that young people who currently do little activity should participate in physical activity of at least moderate intensity for at least half an hour per day.[45] They also proposed that some of these activities (performed at least twice a week) should help increase and maintain muscular strength, flexibility, and bone health.[45]

Nationally, a variety of guidelines have been proposed in the US. The Year 2000 Dietary Guidelines for Americans recommended choosing a lifestyle that combines regular physical activity with sensible eating,[46] while the US Department of Health and Human Services emphasized earlier recommendations by the Surgeon General that moderate physical activity should be regularly performed by people of all ages.[151] Johnson proposed that children should be a healthy weight and physically active at least 60 minutes each day to promote optimal growth and development and to reduce their risk for chronic diseases.[152] The US Healthy People 2010 campaign proposed to increase the proportion of adolescents who engage in vigorous physical activity that promotes cardio-respiratory fitness 3 or more days per week for 20 or more minutes per occasion.[45] It also proposed to increase the number of adolescents who engage in moderate physical activity for at least 30 minutes on five or more of the previous seven days.[46] Borra and colleagues found that children think of physical activity as fun,[150] and went on to comment that if given an appropriate opportunity, together with desirable encouragement, most children will actually choose to be active.[153] It has been suggested that children should choose the activities which they enjoy and those that can be integrated into their daily routine.[46] Furthermore, the physical activities chosen by the children should include muscle strengthening exercises, aerobic fitness exercises, and activities of endurance and flexibility.[153] When choosing desirable and appropriate activities, the American Academy of Pediatrics (AAP) recommended that participation in team sports should be left until the age of 6 years, as until this time children are not able to comprehend the concept of teamwork.[154] Frary and colleagues emphasized however, that physical activity should not need to be strenuous to reap its beneficial effects.[46]

In summary, since the increased incidence of overweight children and childhood obesity, and the presence of at least one amendable cardiovascular disease risk factor in these individuals [85,155] is in fact not a direct result of decreased physical activity,[45] the present scientific evidence suggests guidelines that are justifiably endorsing a cumulative increase in activity. This is seemingly based on the principle that every increase in physical activity can have some favorable health effect for children and adolescents.[45] This simplified and abridged guideline seems much easier to achieve than a quantitative prescription of 30 or 60 minutes physical activity of moderate intensity on a daily basis. Before such a prescriptive guideline can be unequivocally approved for promotion, further experimental studies to validate the relationships between certain health outcomes and different frequencies, durations, modes and volumes of physical activity are still needed.[45, 80]

1.4 INTERVENTION AND PREVENTION STRATEGIES

The IOTF has concluded that it is easier, less expensive and more effective to prevent weight gain than it is to treat obesity after it has fully developed.[156] For this reason, addressing the problem in children who are at the stage of their lives where many lifestyle habits are formed, offers a great and probable opportunity for successfully managing and controlling obesity.[156]

1.4.1 Evidence Available on Timeous Introduction of Intervention and Prevention Strategies

As discussed earlier, the findings of the numerous studies on the independent relationships between childhood weight and adulthood CHD mortality are not yet in agreement.[77] It therefore seems feasible and even necessary, to emphasize the need for both primary and secondary prevention intervention strategies. This notion is supported by Edmunds and colleagues, who commented that prevention of obesity is an essential task in the reduction of the health burden it plays on society, even though the results from available obesity treatment programmes at obesity clinics have been disappointing. [18] It is however noted that children generally do tend to do better than adults.[18]

A raw statistic to support these needs is that overweight children are twice as likely as normal children to be obese adults.[17,18] If one looks at areas such as South Eastern Asia, where almost 20 % of the population is constituted by adolescents,[17] and if one considers the evidence that normal weight children who become obese adults will (to some extent) present with a degree of adverse risk factor levels for the development of CHD and adult morbidity,[74] groups of children at high risk of becoming overweight or obese during adulthood need to and must be identified as early as the primary school level.[57]

As has been demonstrated by the literature reviewed, identifying children at risk of persistent obesity is not an exact science (at least not yet), but current (baseline) body status, [57,77] having an obese same-sex parent,[70] and an early occurrence of the adiposity rebound (at around 5 years of age) [17-18,74-75] seem to the most popular role players in the prediction of obesity in adulthood during childhood.

Much of the current research available has focussed on children aged 5 to 12 years.[18] A study conducted among a representative sample of 1 000 French children between the ages of 9 and 11 years and their mothers (completed in 1993, and repeated in 1995 and 1997), showed that these children also had a high awareness of good nutrition and they viewed food as 'a vital necessity'.[157] It also revealed an interest that the children had about their diet, and that they were enthusiastic about learning about nutrition in general.[157] According to Bellisle and colleagues, children at this age are at a transitional stage concerning food and diet.[157] Still close to their starting years, they prefer simple or sweet foods, but they are also drawn to more sophisticated and exotic meals, and a major focus always remains on the taste and enjoyment of the foods.[157] For this reason there is often divergence between taste and health, when in fact these two elements should not necessarily be opposed.[157] Noting their interest in good nutrition, children at this age are however only interested in nutritional topics which relate directly to their lives at present and on the immediate outcomes that the recommended nutrition can have on them (for example nutrition and physical performance).[157] They are not concerned about the long-term effects of poor nutrition which may track into adulthood.[157]

The prevention and management of obesity in childhood thus seems to be an ideal point for interventions that will aim to influence good eating patterns from an early age, and to introduce eating patterns that will to some extent impact throughout the child's lifetime. Considering that lifestyle behaviours which contribute to and sustain obesity in adulthood are less well established in children and are therefore likely to be more amenable to change,[157] early adolescence can be considered as one of the final stages for integrating population-based childhood primary intervention strategies, with the aim of enforcing successful long-term preventative action, and reducing the need for secondary prevention strategies.[18]

1.4.2 The Role of Family- versus School-based Intervention Programs

Age, gender, ethnicity, socio-economic class, social norms, family composition, attitudes and beliefs, parental knowledge, and children's knowledge, are all characteristics that affect the combination of food intake and physical activity.[75] Family practices associated with food consumption can in turn affect food choice, methods of food preparation and overall consumption.[75] For example, Fisher and colleagues reported that when young children's access to certain foods was restricted, their preference for these particular foods was found to increase.[158] Furthermore, Johnson and colleagues reported that the severe efforts of parents to control their children's food intake were associated with impaired regulation of caloric intake.[159] Parents should thus be in charge of what children are offered and when they are given food, but the children themselves should be responsible for deciding to eat what is being offered or not.[75]

Crawford and colleagues discussed a study of female African-American adolescents, where the weight loss seen in the girls tended to increase as the number of intervention sessions attended by their mothers increased.[21] Edmunds and colleagues supported this by commenting that individual studies have found that parents are better agents of change than children, and so parental training and family therapy are effective in the sense that treating parents and children together can be more beneficial and successful than treating children on their own.[18] Even parents who are themselves obese have an integral role in supporting their children up to about the age of 8 years.[18]

The circumstances in which interventions are delivered and by whom they are delivered are just as important as the contents of the intervention.[18] A recent expert committee's review of ways to prevent and treat childhood obesity (including diet and physical activity), supported the use of family therapy and improving parenting skills for paediatric weight management.[18] Its general recommendations included the need for clinicians to be aware of the prospects of endogenous (genetic or endocrine) causes of obesity; to focus the primary goal of treatment on healthy eating and positive habits of physical activity; to promote counselling for families when the parents believe that obesity is inevitable or when the parents are not capacitated to make changes within the family; to start treatment of overweight and obesity early and involve the family; and to aim for small, incremental changes in behaviour, recognising the need for the ongoing support for families.[18] In terms of behaviour patterns specifically associated with physical activity, family practices again play an important role, such that physical activity is often higher among children with siblings and playmates or among children who live in neighbourhoods where occasions for safe outdoor play exist.[75]

School curricula can alter children's knowledge, beliefs and attitudes, and lead to changes in food consumption or activity levels at school and at home.[75] In a survey conducted by Borra and colleagues, 90% of children reported schools and teachers as their primary source of nutrition and health education.[150] Nicklas stated that schools provide an excellent setting for providing appropriate nutrition for the majority of children, and that continued efforts are needed to include nutrition as a part of comprehensive health education programs.[34] Dr Carmen Perez-Rodrigo from the Nutrition Community Department in Bilbao, also commented on the importance of nutrition education in schools, saying that children as young as five start assuming their own food choices, and so even before that age (at a pre-primary school level), nutrition education should commence with the promotion of adequate food patterns, according to developmental stage.[157]

School feeding programs act as an avenue for achieving the goal of encouraging the public to eat breakfast, although age, sex, race, geographic location, family income, and perceived stigma of the program are all factors which may hinder and influence an individual's willingness and decision to participate.[117] In several developing countries, school feeding tends to increase student attendance because the programs act, to some extent, as an incentive for parents to send their children to school, and consequently the nutritional, educational, and economic value of such school feeding becomes increasingly evident.[117]

For many years now, schools have been seen as essential settings for health education, and in the 1980's, the WHO encouraged a change in focus from the promotion of health behaviours of individuals to the establishment of healthy 'settings' or environments.[160] This shift led to the definition of an eco-holistic approach of health promotion in the Ottawa Charter in 1986, the principles of which resulted in the concept of the 'health promoting school'.[160] This concept encourages a focus on programs with a holistic approach to health promotion, as opposed to programs that are specific to certain health aspects.[160] This initiative has in turn been introduced in SA, and has been embraced by both the Departments of Health and Education.

School based prevention interventions that are incorporated into the normal curriculum or school health promotion services should thus target the whole child (including diet, physical activity, and other educational and psychological components)[16,18,76], and should be implemented based on a multi-level, multi-strategy approach.[160] They should provide an opportunity for frequent contact with the children and consequent opportunities for both the revision and supervision of nutrition education, and the promotion of safe physical activity, within the formal curriculum and informally through a supportive environment such as healthy school meals and breaktime snacks [18,161] , and facilities for physical activities supervised by trained staff [18].

According to Biddle and colleagues,[44] while parental support affects the frequency and intensity of children's physical activity, schools and communities, together with the parents have a greater potential to increase children's activity level through physical education.[46] Efforts must be focussed on getting daily physical education into every school curriculum, and schools should take on a more pro-active role by implementing supportive strategies such as developing policies for the promotion of student health and identifying nutrition issues within the school itself;[76] aiming to make healthier foods available at school and school functions;[76,85] and restricting in-school availability of and marketing of poor food choices.[16,76,85] After the publication in 2002 which stated that less than one-third of black children in South Africa were offered physical education at school,[62] physical education was included into as a sub-component of a life skill orientated segment of the South African school curriculum.[26] This is a clear depiction of the influential capacities carried by our national departments.

In conclusion, it seems that the success of any intervention strategy aimed at the prevention and treatment of overweight and obesity is largely dependent on the incorporation of nutrition education and regular physical activity into the school program, and its reinforcement by the family environment.[157] Pioneering nutrition interventions thus need to include education, counselling, and behaviour modifications, all of which need to be included at the individual, family, community, and public health levels.[21,32,74]

1.4.3 Existing and Proposed Intervention and Prevention Programs

To date, the prevention of childhood obesity seems to have evaded our grasp,[16] and while it is possible to treat obesity, it is often extremely difficult to maintain that weight loss. Also, to date, obesity research in children has mainly been focussed on helping obese children and adolescents to lose weight, while less attention has been placed on preventative strategies.[85]

The goal of any weight loss intervention is to achieve an energy balance where energy intake is less than energy expenditure.[85] Once a desired weight is achieved, goal is to ensure that energy intake equals energy expenditure so that weight can be maintained.[85] Diet and physical activity are the two principal behaviours targeted for promoting weight loss or maintain weight loss,[80,85] while behaviour modification is the tool used to bring these changes about.[85]

One popular intervention program used with younger children and preadolescents in the US is the 'Stop Light Diet'. It aims to help children reduce the energy density of their diets by colour-coding foods as green (foods that can be eaten at any time), yellow (foods with average energy values and that should be eaten with caution), or red (foods that have a high energy density or fat content and in turn should be avoided).[85] This intervention approach has been found to contribute to long-term reductions in overweight status when used as a treatment.[162] Two of the more successful North American preventative programs are the 'Planet Health' and 'Eat Well and Keep Moving' interdisciplinary health behaviour interventions used amongst children and adolescents.[156] Both programs were based on four specific messages that had to be included into the curricula of several subjects by the classroom teachers.[156] These programs were also linked with the school food services teacher and other staff wellness programs.[156] The principles of both interventions concentrated on reducing television viewing, decreasing the intake of high-fat foods, increasing fruit and vegetable intake, and increasing levels and frequencies of moderate and vigorous physical activity.[163-164] Both programs brought about reductions in television watching, increases in fruit and vegetable consumption, while 'Planet Health' also brought about a decrease in the prevalence of obesity in female adolescents.[75,156,163-164]

It is accepted that cultural differences in preoccupations with weight and perceptions of ideal body weights are rife across the globe. Several studies discussed by Crawford and colleagues, conducted amongst American adolescent females, showed that the African American female adolescents reported significantly less dieting compared with their white counterparts.[21] Similar differences have also been noted in South Africa between black and white 13-year old girls.[26] Thus noting that the demographics of the North American population within which the Planet Health was conducted is likely to be vastly different from an age- and gender-matched population in South Africa, the findings from the THUSA study have recently indicated that efforts for the prevention and management of overweight and obesity in South African youth should specifically be focussed on pre-menarcheal girls between the ages of 10 to 13 years.[61] It may therefore be worthwhile to consider a 'Planet Health'-type approach in this population, guarding and adjusting for cultural suitability where possible.

In the North of France, the Fleurbaix-Laventie-Ville-Santé Study is currently in progress. This prospective intervention study hypothesises that nutritional education at school may enhance the nutritional knowledge of children and, in turn influence the dietary habits of the whole family and weight evolution in a 10-year prospective follow-up.[165] This hypothesis has been based on the concept that the role of the child in a prevention campaign is not only that of a target receiving the message, but also that of a partner in the promotion of desirable eating and physical activity within the family environment.[165] Preliminary results indicate that the education program has indeed brought about changes in dietary habits (demonstrated as a decreased intake of lipid-rich foods) in the family, while the long-term changes in body weight remain to be evaluated.[165] The Stanford Obesity Prevention for Pre-Adolescents (OPPrA) trial is yet another ongoing, multi-component intervention trial for the primary and secondary prevention of obesity, and here the sample consists of an ethnically and socioeconomically diverse group of about 1000 third grade children.[85]

The Pathways study is another ongoing, randomised, school-based intervention designed for the primary prevention of obesity in American Indian school children in 7 American Indian communities around the US.[85] This study also implements culturally appropriate strategies for the promotion of healthy eating and increased physical activity.[85] Cultural appropriateness is likely to bring about increased effectiveness and sustained implementation of initiated interventions,[166] and this is particularly relevant and necessary within the diverse context of the South African population.

At a national level, where population-based approaches are necessary, the goal of any weight management intervention program is still the reduction of population exposure to the environmental causes of obesity, and the tool to bring about this change would then take the form of public health education.[85,165]

One of the goals of the World Declaration and Plan of Action for Nutrition campaign strives for the global eradication or significant reduction of diet-related non-communicable diseases.[167] The American Heart Association (AHA) has endorsed a broad set of recommendations for those aged two years and older. These guidelines stress a diet that mainly relies on fruit and vegetables, whole grains, beans, low-fat and non-fat dairy products, lean meat and fish.[76] It also suggests that calorie-dense foods and beverages with minimal nutritional content return to their role as occasional and optional items in an otherwise balanced diet.[76] These recommendations are simplified echoes of the public health dietary guidelines which promote low intakes of saturated and trans fats, cholesterol, added sugar, salt, and energy.[76]

In South Africa, the FBDGs are used as a means of operationalising this same international goal in a culturally sensitive, population-based manner. Various modes of implementation are currently available, focussing on key target groups, settings and approaches, and a strategy for implementing these guidelines in such a way that all South Africans will be exposed to and able to reap the benefits of the guidelines, is currently being prepared.[167] It has been agreed that the success of this intervention is going to depend on its ability to be population-based, integrated, multidisciplinary and multisectorial.[168] Suggestions for their flourishing implementation include that these guidelines be implemented in the Integrated Nutrition Program of the Department of Health, and that they be incorporated as basic nutrition education through the Primary School Nutrition Program and the national education curriculum of the Department of Education.[167]

Other public-level health strategies include the regulation of commercially available, obesity-promoting food items;[85] the limitation and control of marketing of obesity-promoting foods to vulnerable consumers such as children;[16,85] and the introduction of economic incentives through taxation policies and the implementation of 'fiscal food taxes'.[16,85]

The results of exercise in the treatment of youth obesity are not very consistent, but in a study by Epstein and colleagues, lifestyle programs (programs where children were allowed to achieve their energy expenditure goal by partaking in any form of activity at any time during the day without having to necessarily achieve their energy expenditure goal in one bout) were found to be more effective than aerobic programs (programs where children had to choose one exercise to perform each day during one predetermined period) in decreasing the percentage overweight of children.[169] It is possible that these lifestyle exercises are more sustainable (either because they are of a lower intensity, or because they can be completed in several bouts), but the absolute components that make these lifestyle programs successful, still need to determined.[85]

The President's Council on Physical Fitness and Sports in the US highlighted the 'get fit with a friend' approach to increase physical activity among children and adolescents,[150] while the CDC's Nutrition and Physical Activity Program has developed the KidsWalk-to-School community-based program. This program aims to increase the opportunities for daily physical activity by encouraging children to walk to and from school in groups accompanied by adults.[170] In addition to this, the program advocates partnerships between the communities and their schools, Parent Teacher Associations (PTA), local police departments, businesses and local politicians, so as to create an environment that is supportive of walking and bicycling to and from school safely.[170]

In South Africa, the Community Health Intervention Programmes (CHIPs) is an example of a regional initiative for the participation of primary school children in physical activity.[144] It focuses on education to increase awareness on chronic diseases of lifestyle, and implements regular physical activity sessions to encourage adherence and self-efficient lifestyle choices.[144] The problem in South Africa however, is that many communities are lacking basic infrastructure and facilities, and this in turn threatens the feasibility of the now curriculum-instituted physical education.[171] This is particularly evident in the historically disadvantaged communities, as well as in urbanized areas where high levels of violence prevail, with increased risks to personal safety.[171] The South African Society for the Study of Obesity (SASSO) is encouraging the creation and maintenance of child-friendly exercise facilities,[16] and identification and maintenance of these appropriate and accessible environments should form the cornerstones of any public health physical activity policies which the government may be developing.[172]

From a preventative approach, a lot of attention is given to increasing physical activity at an early age in terms of the development of physical activity guidelines and programs for children and adolescents, but the instability of physical activity into adulthood,[149] may suggest that total populations should also be considered as target populations for physical activity intervention programs and that these programs should in fact not be limited to children and adolescents.[45] The current information available on effective programs for the prevention of obesity is not adequate to draw precise, population-appropriate recommendations on how the unique components of a healthy diet and regular physical activity should be implemented,[75,161,173] and the need for well-designed studies that examine a range of prevention strategies still remains a priority.[173] In South Africa specifically, there is a need for evidence-based research that deals with the social epidemiology of obesity.[25] Since no published South African research encompassing insights from the social and health departments exists, issues such as food properties (portion sizes, sugar-sweetened beverage intake, and energy density); socio-economic factors (transportation, availability of food choices, food pricing, occupational inactivity, and child care arrangements); home environmental influences (parental role modelling, school meals, family meals, and TV viewing); and eating behaviours (snacking), need to be explored so as that a comprehensive local model of obesity can be developed.[25]

Currently in the United States, many areas of government are involved in obesity-related activities, but the American Dietetic Association (ADA) supports the creation of a single institute to study the causes of obesity and the factors that may lead to its successful treatment.[20] In South Africa, this single institute is embodied by the South African Society for Obesity Management (SASOM).

Ultimately, the development of effective programs for both the prevention and treatment of obesity and overweight in children and adolescents requires further research to clarify the exact elements that promulgate the development of obesity, as well as their relationships with the natural history of weight gain, dietary intakes, physical activity, and sedentary behaviors.[85]

1.5 CONCLUSION AND MOTIVATION OF STUDY

Obesity is recognizably a chronic disease worldwide [16] and it has been documented that childhood obesity in particular has significant (although unclear) implications for long-term health.[174] Evidence from the two NHANES shows that the components of the gene pool within the United States population specifically have not shown alterations over the 15 years included in these studies, indicating that changes in the prevalence of overweight can most likely be accounted for by the environmental effects of energy balance. With such strong evidence, the global pandemic of overweight and obesity can be ascribed to the same phenomenon .[75] The one major and apparent environmental factor is diet and the increased consumption of high-fat energy-dense diets, and the other is decreased physical activity and the worldwide increase in sedentary behaviors.[156] Although no particular strategy has been identified as the gold standard to be used in the prevention and management of overweight and obesity amongst children and adolescents,[16] and since no existing intervention strategies has yet to have had a significant impact on the obesity epidemic, it has been suggested that passive efforts to reduce these excess caloric intakes and to increase energy expenditure may be at fault.[16,21]

A significant weight loss is difficult to preserve, and so prevention strategies should remain our highest priority.[140] An improvement in any negative lifestyle behavior or modifiable risk factor is 'at the very least a healthy goal to strive for, which is unlikely to do any harm',[16] and from the available evidence it can be concluded that the simultaneous employment of weight loss treatments and weight gain prevention strategies is likely to render the greatest global benefits.[80]

The coexistence of stunting and overweight in low-income populations undergoing nutritional transitions (the complex burden of diseases thriving in South Africa) makes the national promotion of strategies for the prevention and management of overweight and obesity even more crucial, as it is the prevention and treatment of undernutrition that currently remains the main focus and budget of our health services.[24]

This study aimed to provide further insight into the specific relationships between the combinations of the various modifiable risk factors (including regular RTEC breakfast and snack consumption, and regular increased physical activity) with the anthropometric measures of body weight, percentage body fat, and BMI as an indicator of adiposity in a population of young adolescents in an urban province of SA. It also aimed to provide information for the development and implementation of scientifically sound intervention programs, which would focus on the modification of these identifiable risk factors, for the prevention and management of overweight and obesity in this target group.

CHAPTER 2: METHODS

2.1 AIM

To determine the effect of regular increased physical activity, and regular consumption of Ready-To-Eat-Cereal breakfasts and afternoon snacks on the weight and percentage body fat, of young adolescents attending public Gauteng schools.

The following objectives were identified for investigation amongst this group of young adolescents attending public Gauteng schools:

a) To determine the effect of regular increased physical activity, in the presence of usual *ad libitum* daily diet, on:
   - Body weight
   - BMI classification as a universal measure of adiposity
   - Percentage body fat as calculated by Bioelectrical Impedance

b) To determine the effect of regular consumption of RTEC breakfasts and afternoon snacks, in the presence of usual daily physical activity, on:
   - Body weight
   - BMI classification as a universal measure of adiposity
   - Percentage body fat as calculated by Bioelectrical Impedance

c) To determine the effect of a combination of regular consumption of RTEC breakfasts and afternoon snacks, and regular increased physical activity, on:
   - Body weight
   - BMI classification as a universal measure of adiposity
   - Percentage body fat as calculated by Bioelectrical Impedance

2.2 HYPOTHESIS

A combination of regular increased physical activity, and regular consumption of RTEC breakfasts and afternoon snacks, will result in the greatest cumulative changes (decreases) in body weight, BMI classification and percentage body fat, amongst young adolescents, from the selected public Gauteng schools.

2.3 STUDY TYPE

The study design was a randomised controlled trial including either stepping or RTEC consumption interventions, both interventions combined or no intervention, in four separate cohorts.

2.4 STUDY POPULATION

2.4.1 Target Population

The population targeted consisted of cross-cultural, male and female, English speaking children aged 10-13 years attending public Gauteng schools.

2.4.2 Sampling of Schools

Schools were included in the sample if they were listed as a public school as per the records of the Gauteng Department of Education (GDE) at the time of the data request during April 2006, if they were situated in the Ekhurhuleni East and West districts of Gauteng, if they were unisex institutions, if English was used as the primary mode of communication (i.e. daily lessons at the selected school were not given in any language other than English, excluding lessons for second and third languages), and if the headmaster and/or governing body of the school provided consent for pupils to participate in the projected study.

One school from the Ekhuruleni East district of Gauteng, and another school from the Ekhuruleni West district of Gauteng were selected. This selection was based on convenience sampling since both schools were in close proximity of each other and in close proximity of the investigators place of employment.

2.4.3 Sampling to Cohorts: Pupil Selection

Pupils were included in the sample if they were grade five, six or seven pupils from the selected schools, if they were between the ages of 10 and 13 years at the time of selection, if they were present at the initial program presentation to receive an information letter (Addendum 2), and in turn if they consented to participate by completing and timeously returning the general consent form (Addendum 3) and participation questionnaire (Addendum 4). Pupils were excluded from the sample if they presented with any diagnosed or self-reported allergies, if they reported to be following any form of therapeutic diet, if they reported to be or intending to be fasting for more than one day at a time at any point during the designated study period, and if they reported to be unable to comfortably communicate (either read, write or speak) in English.

The pupils from each school had to have returned their completed consent forms and questionnaires by the first Monday thereafter, and the pupils who in turn were not associated with any of the exclusion criteria (as per their responses in the participation questionnaires) were allocated a place in the study sample. These qualifying participants were randomly allocated to one of the four study cohorts, based on a systematic randomised sampling procedure. All the returned consent forms (212 in total) were arranged into piles based on the pupil's homeroom class, and class lists were drawn up accordingly. The class lists did not record the pupils alphabetically, but rather in the random order in which the pupils returned their consent forms. The class lists (Addendum 5) included columns indicating whether the participant was willing to consume the specified RTEC products and snacks, and to indicate whether the participant was willing to complete the stepping intervention. The individual class lists were then arranged in numerical and alphabetical order per school (i.e. grade 5 A, 5 B, 6 A, 6 B and 6 C of school one, followed by grade 5 A, 5 B, 6 A, 6 B and 6 C of school two). The pupils were numbered from one through to 212, starting with Grade 5 A of school one and working through to Grade 7 C of school two. Starting with participant one, each participant was allocated to the one of the four cohorts, with the allocation order being repeated after every four participants. If a participant was allocated to one of the intervention cohorts, and the participant had indicated in the participation questionnaire that he/she was not willing to complete the specific intervention, the participants' group allocation was swapped with the next participant allocated to another cohort on the list.

The control cohort (Control) had no prescribed intervention, Step cohort (Step) had prescribed stepping intervention only, RTEC cohort had prescribed RTEC consumption intervention only (RTEC), and Step and RTEC cohort (Step & RTEC) had both prescribed stepping and RTEC consumption interventions. These abbreviations will be used throughout the thesis to describe the 4 cohorts.

Each cohort then consisted of 53 participants. In order to achieve a confidence interval of 95 %, and an error % or precision (Cp) of 14 % from the large Grade five, six and seven pupil population of public schools in the Ekhuruleni East and West districts of Gauteng, the sample size of each cohort needed to be at least 49 participants. It was not possible at this stage to recruit more participants as this would have entailed approaching and inducing yet another school that could meet all the specified inclusion criteria. Apart from the limitation placed on this option by the restricted school term duration, the inclusion of another study site would have rendered the execution of the study logistically unfeasible for the single investigator.

2.5 METHODS OF DATA COLLECTION

2.5.1 Logistical and Practical Considerations

A time was scheduled with the headmasters of each of the two selected schools, so that the investigator could present a brief overview of the study to all the grade five, six and seven pupils of each respective school. At this meeting, each attending pupil was given an information letter for their parent(s) (Addendum 2), a general consent form detailing the study for the parents (Addendum 3), and an additional participation questionnaire (Addendum 4). The information letter to the parents introduced the investigator and the proposed study, requested the completion and return of the initial consent form to the participants' class teacher by the first Monday thereafter, and mentioned the incentives being offered to the participants. The incentives referred to four 'Cross trainer' vouchers that were randomly awarded to one participant from each of the four cohorts after completion of the study. The participants qualified for inclusion into this random draw if he/she returned a completed 'Loving Lifestyle' food/activity diary at the end of the five week study period. The intention of this incentive was purely as a source of motivation for the participants to keep accurate records of their intake and activity over the study period, in an attempt to enhance the reliability of the results. The investigator's contact details were made available on all three of the above-mentioned documents, allowing the parents to easily contact the investigator in the event that they had any questions related to participation in the study.

The four cohorts to which the participants were randomly allocated included the 'no intervention' cohort, the 'stepping intervention' cohort, the 'RTEC consumption intervention' cohort and the combined 'stepping and RTEC consumption intervention' cohort. The participants of all the cohorts were required to perform a number of baseline tasks over the 5-week study period (weekends excluded).

They were required to wear a pedometer, positioned as specified by the device instructions, from the beginning of the first class to the end of the last class, on each school day of the five-week study period, and to document the total number of steps recorded by his/her pedometer at the end of each school day during the 5-week study period. He/she was required to document participation in any other form of physical activity on each weekday of the 5-week study period (the type of physical activity and the duration of his/her participation in the activity had to be recorded). He/she also had to record all the items of food which he/she consumed for breakfast on each weekday of the 5-week study period (the type of food and the amount consumed both had to be recorded). The participant was also required to record all the items of food consumed as an afternoon snack on each weekday of the 5-week study period (the time it was consumed, the type of food consumed and the amount consumed had to be recorded). Lastly, the participants had to record any additional consumption (i.e. at any time other than at breakfast and/or as an afternoon snack during the day) of RTEC product(s) (i.e. any product listed as per Addendum 6) on each weekday of the 5-week study period. In this case, the time it was consumed, the meal he/she felt it should be classified as, the product description, and the portion consumed had to be recorded.

The 'stepping intervention' cohort required that the participants complete the stepping intervention in addition to the baseline tasks. This intervention required that the participants aim to complete a minimum of 2 000 steps in a 20-minute exercise session on three separate weekdays during each week of the 5-week study period. The number of steps completed and the time in which they were completed had to be recorded. These steps could be completed during the break periods during the school day or after school, as preferred by the participant.

The 'RTEC consumption' cohort required that the participants complete the RTEC consumption intervention in addition to the baseline tasks. This intervention required that in addition to recording all the items of food consumed for breakfast and as an afternoon snack on each weekday of the 5-week study period, the participants had to consume and record the consumption of a specified portion of a pre-selected Kellogg's intermediate-GI RTEC with low fat milk on each of the weekdays of the 5-week study period, and a specified RTEC snack bar as an afternoon snack on each of the weekdays of the 5-week study period.

The Kellogg's range of children's RTEC are all made from real grains of rice (Coco Pops and Strawberry Pops) or corn (Frosties), and are enriched with 20 % of the recommended dietary allowances (RDA) for nine essential vitamins (vitamin A, folic acid, vitamins B6 and B12, and other B vitamins) and iron.[175] These cereals are low in fat (containing less than 3g of fat per 100g of the product), and are also pre-sweetened.[175] No health effects, other than an association with dental caries have been conclusively found to be related to sugar consumption, and there is no direct connection between the intake of added sugars and obesity.[176] The Kellogg's children's cereals used in the study all had an intermediate GI (Strawberry Pops has a GI of 60, Frosties a GI of 67 and Coco Pops Crunchers a GI of 68) which in turn was lowered when consumed with milk. The GL values of the cereals used were also all below the GI Foundation of South Africa's recommendation that the GL of a meal should be 25-30 (Strawberry Pops has a GL of 16, Frosties a GL of 24 and Coco Pops crunchers a GL of 18).[175]

The combined 'stepping and RTEC consumption' intervention cohort required the participants to complete both the stepping and the RTEC consumption interventions in addition to the baseline tasks.

A time was then arranged with the headmasters and co-ordinating teachers from each of the participating schools, so that the investigator could meet with the selected and cohort allocated participants. The meeting times were arranged so that each cohort from each school could attend separate morning orientation sessions. At each of the cohort specific orientation sessions, the participants were thanked for their willingness to participate, and each participant received his/her 'Loving Lifestyle' material package. Each 'Loving Lifestyle' material package included a welcome letter confirming the participant's cohort allocation (Addendum 7), a 'Loving Lifestyle' food/activity diary (Addenda 8-11), a set of measuring cups and a pedometer.

During the cohort specific meetings, the contents of the 'Loving Lifestyle' packages were checked by each participant as the investigator verbally listed everything that was to be found in the package. An overview of the calendar in the 'Loving Lifestyle' diary was discussed to emphasise the assessment dates and the weekly meeting dates (Addendum 12). Participants from the two schools and the various classes were scheduled to start on one of four days during the week that the study was scheduled to commence, and the assessment dates and weekly meeting dates varied from one school and class to the next. This was done simply to allow the investigator enough time to co-ordinate, assess and meet with the participants on their scheduled days of assessments or meetings.

An overview of the cohort specific responsibilities of the participants was presented and the prescribed tasks were discussed in more detail when the methods of completing the 'Loving Lifestyle' food/activity diary were discussed and demonstrated. The recording section of the diary was divided into 5 weeks. Each week started with a 'weekly exercise page' (Addendum 11), followed by a dated page, each displaying the five baseline recording sections (Addenda 9,10). Section one allowed for the recording of any breakfast that may have been consumed (including a space for recording the portion consumed). Section two allowed for the recording of any afternoon snacks that may have been consumed (including a space for recording the time it was consumed, and the portion consumed). Section three allowed for the recording of any RTEC products that may have been consumed at a time other than at breakfast or as an afternoon snack, and here a space was provided for recording the time the product was consumed, the meal that the participant felt it formed part of, the product details (manufacturer, product name and product description), and the portion consumed. Section four then allowed for the recording of the participants' daily steps, as detailed off the pedometer.

For the cohorts where no stepping intervention was prescribed, section five (Addendum 9) allowed the participant to indicate whether he/she had participated in any additional activity on that specific day (in which case the additional activity would then be recorded on the 'weekly exercise page'). For the cohorts where a stepping intervention was prescribed, section five (Addendum 10) allowed the participant to record whether he/she had completed the stepping intervention on that particular day, and if so, how many steps had been completed and how long it took to complete these steps. It also allowed the participant to indicate whether these steps were completed during school or after school hours. Section six then allowed these participants to indicate whether they had participated in any additional activity on that specific day (in which case the additional activity would then be recorded on the 'weekly exercise page').

At these cohort specific meetings, the participants were also familiarised with the RTEC and RTEC snacks available on market as per the product lists that were included in the food/activity diary (Addendum 6). Samples of the listed products were displayed and shown to the participants, and the participants were practically shown how to measure (using the provided set of measuring cups) and document the portion size of the RTEC products they consumed. For the cohorts where a RTEC consumption intervention was prescribed, pre-packaged 40 g sample portions of Frosties and Strawberry pops were also circulated amongst the participants to allow for further visual reinforcement of the prescribed portion size. Furthermore, a few practical examples of 24-hour recalls were presented to all the groups using the overhead projector. This allowed the participants to actively participate in selecting the data that would be relevant for inclusion in their food/activity diaries, and to visually interpret how the data had to be recorded.

The use and positioning of the pedometers was also demonstrated. All participants were required to position their pedometers on the waistband of their skirt or trousers for the females and males respectively, and each participant was then checked by the investigator and the position of the pedometer corrected accordingly. Finally, the care of the pedometer was discussed as per the instructions on the pamphlet provided with the product, and the participants were given a further opportunity to ask questions. The investigator provided feedback, re-emphasis and answers where appropriate and relevant.

At the end of these scheduled cohort specific meetings, the participants in the two cohorts with prescribed RTEC consumption interventions were provided with all the required consumption items (the RTE breakfast cereals, RTEC snacks and the low fat milk for the consumption of the RTE breakfast cereals). These were all sponsored by Kellogg's and Clover respectively. Each participant in these two cohorts received four boxes of RTE cereal labelled with dated stickers for each day that a 250 ml (40 g) serving of the particular RTE cereal would have to be consumed for breakfast, a pre-packaged packet of a 250 ml (40 g) portion of Strawberry Pops and a pre-packaged packet of a 250 ml (40 g) portion of Frosties as samples allowing the participants to familiarise themselves with the single RTEC servings being specified, and 30 RTEC snack bars labelled with dated stickers for each day that a single snack bar would have to be consumed as an afternoon snack. The participants in these two cohorts also each received eight litres of Clover ultrahigh temperature (UHT) low fat milk, but this was only issued on the day of their initial assessment.

On the day of their initial and final assessments, the participants in all four cohorts were subjected to a five-minute assessment, where weight, height and percentage body fat assessments were completed. At the initial assessment only, the participant's socio-demographic background and stride length (for the setting of the pedometers) were also assessed.

Both the parents and the teachers were made aware of the participants responsibilities in the study [the class teachers attended the recruitment and cohort specific meetings, and the parents received general consent forms detailing the responsibilities of each of the cohorts (Addendum 3), as well as a later information letter issued to each child, detailing their responsibilities based on the cohort to which they had randomly been allocated (Addendum 7)]. It was deemed essential that the parents and teachers be involved in reminding the participants to complete their diaries as it was a substantial amount of information that needed to be recorded, and self-reporting in these younger age groups can be questionable. An older sample was not chosen as it was important to select participants in the pre-adolescent stages of maturation, so as to avoid the confounding effects of pubertal changes on outcomes of adiposity measures. The teachers were thus involved in the daily reinforcement and encouragement of the participants as the investigator was only able to physically meet with the cohorts once every two weeks (a Wednesday morning meeting was alternated on a weekly basis between the two schools). The parents were involved in ensuring the daily consumption of the RTEC breakfast cereals and RTEC snack bars as afternoon snacks amongst the participants in the RTEC and Step&RTEC cohorts, and then again as a source of reinforcement and encouragement to the participants for the completion of their designated tasks and daily completion of their diaries.

2.5.2 Obtaining Socio-demographic Data

The date of birth, age in years and months, sex and race of each participant was obtained through face-to-face interviewing of each participant at the initial assessment. The data was captured in section 1 of the standardised data capturing form available for each participant (Addendum 13).

2.5.3 Obtaining Anthropometric Data

The investigator performed all the anthropometric measurements on all the participants, at both the initial and final assessments. All the data was captured in section 2 of the standardised data capturing form available for each participant (Addendum 13). All the assessments were done using standardised equipment and techniques. Each assessment lasted approximately five minutes, and the assessments were conducted according to a pre-determined assessment schedule. Assessment of the participants from each of the two schools was scheduled to run over a period of two days at each school i.e. 2 days each for the initial assessments at school A and B, and another 2 days each for the final assessments at school A and B. The assessments were done in the main school hall of each of the respective schools. The participants were called out of class in groups of six, for half an hour (i.e. six participants were assessed every half hour). The one end of the hall was equipped with a desk where the investigator's assistant completed the participants' socio-demographic questionnaires, and the participants were allocated a seat in the queue of chairs set up next to the above-mentioned assistant's station. The other end of the hall was equipped with the body composition monitor, the stadiometer, and the area demarcated for measuring the participants stride length. The hall's floor area was flat/smooth and a wall that was level with the floorboards was used for setting up the stadiometer.

The above described order of activity allowed the investigator's assistant to first complete the participants socio-demographic questionnaire, followed by the investigator completing the anthropometric assessment and measuring the participants stride length, and this was then finally followed by the programming of the pedometer by the investigators assistant.

2.5.3.1 Weight

a) Measuring instrument

A calibrated electronic, portable Tanita Innerscan body composition monitor (Model BC-532) was used to measure weight.

b) Measuring procedure

The participant was asked to stand still in the middle of the scale's platform without touching anything and with the weight evenly distributed on both feet. The weight was recorded to the nearest 0.1 kg.[177]

c) Precautions to ensure validity and reliability of measurement

Validity: To ensure construct validity of the scale measurements, the investigator zeroed and calibrated the scale [177] on each new assessment day, using a standard measure of 5 kg (a 5 kg dumbbell). The investigator also weighed the 5 kg dumbbell after every 20th participant assessment, to ensure that the scale remained calibrated throughout the course of the assessment day.

Reliability: To ensure inter-rater reliability of the measurements, an electronic scale for weight measurements rendered the readings less susceptible to human error.[177] To ensure test-retest reliability, the same scale was used to measure the weight of the participants at both the initial and final assessments. Reliability of the measurements was also enhanced by ensuring that the participants wore the same light clothing at both the initial and final assessments. They wore their basic school uniforms without any accessories such as jackets and scarves, and shoes, socks and stockings were removed before measuring.[178] Feet were cleaned (wiped and dried) before stepping onto the measuring platform' and heels were correctly aligned with the electrodes on the measuring platform.[178] The initial and final assessment readings for each individual participant were taken at the same time of the day on both assessment occasions,[178] since the schedule for the initial assessments was simply repeated in the same order for the final assessments. Two successive measurements were taken to ensure agreement within 0.1 kg,[177] and the scale was placed on tiled floor i.e. a hard, flat surface, where there was minimal vibration to ensure safe and accurate readings.[178]

2.5.3.2 Height

a) Measuring instrument

A portable SCALE 2000 stadiometer was used to measure height.

b) Measuring procedure

The participant was asked to stand with heels together, arms to the side, legs straight, shoulders relaxed, and head in the Frankfort horizontal plane. Heels, buttocks, scapulae, and the back of the head were, as far as possible, aligned against the vertical surface of the stadiometer. Just before the measurement was taken, the participant was asked to inhale deeply, hold his/her breath, and maintain an erect posture, while the headboard was lowered onto the highest point of the head with enough pressure to compress the hair. The measurement was read to the nearest 0.1 cm.[177]

c) Precautions to ensure validity and reliability of measurement

Validity: To ensure construct validity of the meter measurements, the investigator had the height meter calibrated by the distributing company before each of the initial and final assessment days, as the scale was moved and transported to the next location between each of these assessment days.

Reliability: To ensure test-retest reliability, the same height meter was used to measure the height of the participants at both the initial and final assessments. Furthermore, the measurement was read with the eye level to the headboard.[177] All hair ornamentation was removed,[177] and the bottom of the door against which the stadiometer was aligned, was level with the tiled floor.[177] Two successive measurements were also taken, and the average value was used.[177]

2.5.3.3 Percentage body fat

a) Measuring instrument

Tanita Innerscan body composition monitor (Model BC-532) was used to measure percentage body fat.

b) Measuring procedure

The Tanita body composition monitor calculates body composition using Advanced Dual-Frequency Technology' and is superior to basic bio-electrical impedance analysis (BIA) technology, providing highly accurate readings.[178] Safe, low-level electrical signals are passed through the body via the patented Tanita footpads on the monitor platform, and a signal easily flows through fluids in the muscle and other body tissues, while meeting resistance as it passes through body fat which contains little fluid.[178] This resistance is called impedance.[178] The impedance readings are then entered into medically researched mathematical formulas to calculate body composition output, which includes percentage body fat, total body water percentage, visceral fat level, basal metabolic rate, metabolic age, muscle mass and bone mass.[178] In this study, only percentage body fat was recorded.

c) Precautions to ensure validity and reliability of measurement

In addition to the points discussed under 2.5.3.1 (c), construct validity and test-retest reliability were further enhanced by ensuring that the participants urinated upon arriving at the hall for their assessments.[142,179], and assessing them at the same time [142] on the mornings of their initial and final assessments. This was done so as to account for the fact that water (which constitutes up to 60 to 65% of an individuals' body weight) is the most variable component of FFM, and the state of hydration can induce fluctuations of several kilograms.[5] Furthermore, test-retest reliability was ensured by using the same instrument for the assessment of all the participants, on both the initial and final assessment days.[180]

d) Validity of measuring instrument

No gold standard exists for paediatric body composition measurements other than that of chemical analysis.[181] This however is cumbersome in children and the data is sometimes confounded by variability in maturation, diet and activity level.[182] In the absence of a more practical gold standard then, the three-compartment model based on measurement of total body water and body density is deemed acceptable as a reference in children.[181] This however, was still not practical as a field method of assessment of body composition in this particular study due to inability to measure body density. TANITA foot-foot BIA systems in turn, are very practical in paediatrics, although they reveal the greatest bias and widest limits of agreement when compared with BODPOD software, body density, total body water and skinfold assessment methods.[181] TANITA systems rendered a mean error of 2.3 kg for fat mass in adolescent boys, with limits of agreement being 2.3 ± 7.8 kg.[181] All of the above-mentioned techniques (including TANITA foot-foot BIA systems) are considered to currently be acceptable methods of body composition in paediatrics, and the relatively poor accuracy of these existing methods need to be accepted until such time that future research produces appropriate reference data (required to aid in the correct interpretation of results), and improves the accuracy of simple field and clinical methods of body composition estimation.[181,182]

2.5.3.4 Daily physical activity data

a) Measuring instrument

A Kellogg's pedometer was used to record the total number of steps taken by each participant during each school day, over the five-week study period. In the 'stepping intervention' and the combined 'stepping and RTEC consumption intervention' cohorts, the pedometer was also used to measure the participants' steps during the stepping intervention that needed to be completed on three separate occasions during each week of the five-week study period. The daily steps completed during the school day (baseline daily activity), as well as the additional steps (regular increased physical activity) completed by participants in the two above-mentioned cohorts, were recorded by the participants in their individual 'Loving Lifestyle' food/activity diaries (Addenda 9,10). The pedometers used were made in China by Blue Chip Marketing (UK Product Number SK01), and were donated by Kellogg's. The participants also used a self-recording weekly additional exercise/activity document (Addendum 11).

b) Measuring procedure

The step counter counts walking steps according to the movement of the waist. The step counter is first activated by pulling out the white plastic tab on the back, so as to engage the battery.[9] Before the counter could start counting the participants steps, the participants' stride length and weight had to be set. The participants' stride was measured by the investigator at the initial assessment, and could be set between 30 and 180 cm.[9] The participant was instructed to take 10 natural steps, and this was then used to calculate his/her average stride (i.e. total distance walked in centimetres divided by ten steps). The investigator's assistant then entered the measurement into the counter as per the instruction pamphlet. The weight could be set to between 10 kg and 150 kg,[9] as per the instruction pamphlet.

Once the counter had been set to each individual's specifications, the counter was used to count steps. The participants had to press the start/stop button each time they started walking and then again each time they stopped walking. This would activate and then deactivate the counting mechanism.[9] The counters were worn during each school day for the five-week study period, from the time that the first class started, until the time that the last class ended. The counters had to be reset each morning.

If participants in the 'stepping intervention' and combined 'stepping and RTEC consumption' cohorts chose to complete their stepping intervention during school hours, the pedometer did not have to be reset to measure the total number of steps taken during the 20-minute stepping session. Instead, the pedometer reading before the stepping session and after the stepping session had to be recorded in the participants' 'Loving Lifestyle' diary (Addenda 9 and 10). If participants in the 'stepping intervention' and combined 'stepping and RTEC consumption' cohorts chose to complete their stepping intervention after school hours, the pedometer had to be reset to measure the total number of steps taken during the 20-minute stepping session, and the pedometer reading at the end of the stepping session had to be recorded in the participants' 'Loving Lifestyle' diary (Addendum 9,10).

Using the self-recording weekly exercise document that was provided in the 'Loving 'Lifestyle' food/activity diary (Addendum 11), the participants were required to document their participation in any other form of physical activity (other than the prescribed stepping intervention) on each weekday of the 5-week study period. They had to document the type of physical activity and the time spent partaking in the physical activity.

According to the Food and Nutrition Board, the National Research Council and the National Academy of Sciences,[3] the various forms of physical activity can be categorized as resting, very light, light, moderate and heavy physical activity, depending on the estimated caloric expenditure per minute (kcal/min) when engaging in the respective form of physical activity (Table 2.1).

Table 2.1: Categorization of physical activities

Level of physical activity	Type of physical activity
Resting	Sleeping and reclining
Very light	Seated and standing activities such as painting, typing, playing cards or playing a musical instrument
Light	Walking on a level surface at 4.025 – 4.830 kilometers per hour, golf, and table tennis
Moderate	Walking at 5.635 – 6.440 kilometers per hour, cycling, skiing, tennis and dancing
Heavy	Basketball, climbing, soccer, running, rugby and swimming.

Source: Johnson RK. Energy. In: Mahan LK, Escott-Stump S, editors. Krause's Food, Nutrition and Diet Therapy. 10th edition. London: WB Saunders Company; 2000. Chapter 2. p.22.

A reference list (Addendum 14) was compiled for the allocation of these recorded activities to the appropriate activity level category i.e. 'very light', 'light', 'moderate' or 'heavy' physical activity.

c) Precautions to ensure validity and reliability of measurement

Validity: The pedometer was calibrated according to each participant's weight and stride length as per instructions,[9] and the participants were instructed to reset the counter each day for valid daily measurements.[9] According to Stone and colleagues, pedometer counts, controlled for weight, leg length and age, account for 85-94 % of measured energy expenditure.[183] By controlling for weight (individually assessed and programmed into pedometer), leg length (individually measured and programmed into pedometer) and age (homogenous across the group), activity-monitor validity was controlled for.[183]

Reliability: To ensure that the pedometer counted the number of walking steps accurately, the participants were instructed to wear the pedometer vertically, and approximately 15 cm to the left or right of the central line of the waist on the hip bone.[9] The participants were also advised not to drop or expose the pedometer to water or extreme temperatures,[9] that only the recommended batteries were to be used,[9] and that the counter was not, at any point, to be taken apart and then reassembled.[9] Once the step counter was activated for the day, the participants were advised to switch the counter to distance mode, to prevent the counter from accidentally being switched off.[9]

d) Validity of measuring instrument

A pedometer is a useful and objective indicator of daily step counts assessing daily physical activity, although it cannot reflect the intensity of patterns of activity.[184] In turn, validated pedometers have also been found to provide an accurate assessment of adolescent physical activity specifically.[185] However, in a study of inexpensive stepping meters (such as the meters sponsored for use in this study), De Cocker and colleagues found that only 25.9 % of the meters met the criterion of a validated pedometer.[186] Approximately 74.1 % of these inexpensive stepping meters were found to make over- or under-estimations of more than 10 %, while 64.8 % of the meters showed an over-estimation of the actual steps taken by the participants.[186] Nonetheless, since the same inexpensive pedometers were used by the group as a whole, the errors in estimation can be considered to be consistent across the group, and amongst the participants of the various cohorts.

2.5.3.5 Daily servings of RTEC products consumed

a) Measuring instrument

A self-recording food diary (Addenda 9,10) was used to measure daily servings of RTEC products consumed.

b) Measuring procedure

The participants had to record the food items that they consumed for breakfast (type of food and quantity consumed). If a RTEC was consumed for breakfast (provided it was not a bar), the participant had to measure the portion consumed, using the set of measuring cups that each participant received in their material package.

The participants also had to record the food items that they consumed for their afternoon snack (type of food and quantity consumed). If a RTEC was consumed as an afternoon snack (provided it was not a bar), the participant again had to measure the portion consumed, using the set of measuring cups that each participant received in their material package.

When a RTEC product (cereal or snack bar) was consumed at any other time during the day (i.e. any time other than at breakfast and/or as an afternoon snack), the participant had to record the time that the RTEC or RTEC snack bar was consumed, the meal time they felt the RTEC item consumed formed part of (i.e. morning snack, lunch, dinner or evening snack), the product details (including the manufacturers name, the product name, and the product description such as the product flavour), and the portion consumed.

The participants were instructed to pour the desired cereal portion into a bowl, and then before adding the milk, they were required to record the estimated volume of cereal in the bowl (using the volumes provided by the measuring cups). These volumes were then converted into servings by the investigator during the data capturing phase of analysis, using the standardised conversion list

(Addendum 1). The serving conversions were based on a 40 g portion as a standard, single RTEC serving. In the case of RTEC snacks, each bar was considered to be a single serving. The participants were encouraged to collect the RTEC snack packaging and wrappers of any items consumed that were not listed in Addendum 6. These were then to be handed in together with the 'Loving Lifestyle' food/activity diary for addition to the standard conversion list (Addendum 1) by the investigator for data capturing purposes. However, no additional RTEC snack packaging or wrappers of items not listed in Addendum 6 were returned.

c) Precautions to ensure validity and reliability of measurement

A list of all the available products on the market that are considered by the investigator to be RTE cereals and RTEC snacks, was included in each 'Loving Lifestyle' food/activity diary (Addendum 6), and this acted as a reference in the case that the participant was unsure as to whether a particular consumed product was to be reported or not. Standard measuring instruments were also used to estimate portion sizes of RTEC consumed.

2.6 PILOT STUDY

The traditional format of a pilot study was not followed as this study included an in-depth training session for the participants before embarking on the study. As the completion of the diaries for RTEC consumption and activity was to be covered in great depth during the training sessions held prior to the study and included a practice session, it was decided to only test the practicality of the use of the pedometers for the pilot study. One of the participating classes was randomly selected to assist in this regard and the testing was conducted over the course of five school days. As not all the children were going to receive RTEC, it was decided not to pilot the handing out of products and their consumption to avoid creating expectations, as well as to limit additional costs for the sponsors. All the products provided had labels indicating which day they were to be consumed and this was also covered in great depth during the training session. The pilot study therefore assisted in testing the practicality of using the pedometers only and in identifying logistical problems. Solutions to these problems were then highlighted when the participants were given the instructions for using their pedometers during their training sessions. The pedometers were not programmed according to the individual participants' requirements for the pilot study, as the focus was simply on the practicality of wearing the pedometers throughout the school day. A standard stride of 70 cm was used. Each participant was given a checklist to complete at the end of each day during the pilot study (Addendum 15), and the feedback was reviewed by the investigator before commencing the actual study.

2.7 DATA ANALYSIS

A statistician appointed by the Faculty of Health Sciences, Stellenbosch University, was available for consultation regarding the tests to be used for the analysis of the data. The data were analysed by the investigator using both descriptive and inferential statistics. The continuous and ordinal variables were presented as calculated means, standard deviations, and confidence intervals (CI), while the nominal data will be presented as frequency tables. When continuous response variables were compared with nominal input variables the analysis was done by means of an appropriate Analysis of Variance (ANOVA), or a non-parametric ANOVA if the ANOVA residuals were either non-normally distributed or the response variable was of ordinal nature. When nominal response variables were compared with nominal input variables, appropriate contingency tables were used to compute chi-square statistics or Pearson chi-square statistics where appropriate. When continuous response variables were compared with other continuous input variables, appropriate regression or multiple regression methods were used. A significance level of $p<0.05$ was used for a Type 1 error rate α.

2.8 ETHICS AND LEGAL ASPECTS

2.8.1 Ethics Review Committee

The final protocol was submitted to the Human Research Committee, Faculty of Health Sciences, Stellenbosch University, for ethics approval. Ethics approval was granted and project number N06/07/139 allocated (Addendum 16). Permission from schools was granted verbally by the respective principals and grade controllers.

2.8.2 Informed Consent

Each participant pair (participant and parent/guardian) were provided with a cohort specific informed consent and assent form respectively, by the investigator. The standard informed consent and assent form used by the Faculty of Health Sciences of Stellenbosch University was adapted for this specific research study, to accurately represent the responsibilities of the participants in each of the four cohorts (Addendum 3).

2.8.3 Participant Confidentiality

Participant identification information was omitted from all study related assessment materials to ensure participant confidentiality. Upon entering the study, each participant received a participant identification number, which was used on all assessment related study material and documentation. This participant identification number was the same number (from one to 212) allocated to the participant as per his/her position on the class lists drawn up for the random allocation of the participant’s to the cohorts. The participants were also ensured (both verbally and by means of the informed consent and assent forms) that all the assessment information collected by the investigator would be regarded as confidential. Data collected by the investigator was only used for the specified study, and was not shared for any other purposes.

CHAPTER 3: RESULTS

3.1 SAMPLE DEMOGRAPHICS

Three hundred and fifty (350) grade 5-7 children between the ages of 10-13 years were invited to participate. At the start of the study, 212 participants returned consent forms and were randomly allocated to one of the four cohorts, indicating a response rate of 60.57%. There was however only a 56.1% compliancy with 119 participants returning completed "Loving Lifestyle" diaries. Of the participants who completed the study, 10 % were classified as being obese, 69 % as being normal weight and 21 % as being overweight at the start of the study. The gender distribution of this sample included 68.91 % females and 31.09 % males, while 61.35 % were White, 26.89 % Black and 11.76 % Indian (Table 3.1).

Table 3.1: Gender and race distribution across the four cohorts for participants having completed the study (n=119)

COHORT / INTERVENTION	Sample number (n) (%)	GENDER number (%)		RACE number (%)		
		Female	**Male**	**White**	**Black**	**Indian**
Control	**31**	**21**	**10**	**17**	**12**	**2**
	26.05	67.74	32.26	58.84	38.71	6.45
Step	**29**	**24**	**5**	**17**	**6**	**6**
	24.37	82.76	17.24	58.62	20.69	20.69
RTEC	**34**	**17**	**17**	**24**	**5**	**5**
	28.57	50.00	50.00	70.59	14.71	14.71
Step & RTEC	**25**	**20**	**5**	**15**	**9**	**1**
	21.01	80.00	20.00	60.00	36.00	4.00
TOTAL	**119**	**82**	**37**	**73**	**32**	**14**
		68.91	31.09	61.35	26.89	11.76

3.2 PHYSICAL ACTIVITY

3.2.1 Comparison of Variables of Physical Activity between the Cohorts

The mean baseline daily activity (i.e. the mean daily steps recorded during each school day over the course of the 5-week study period) was 82 803 (SD 22 578) steps and there was no significant difference across the four cohorts (Addendum 17). The mean baseline days on which participants engaged in additional activities (i.e. any other activity performed over the course of the 5-week study period, other than the stipulated stepping (where prescribed) was 12.67 (SD 7.25) days and there was no significant difference across the four cohorts (Addendum 17). There was also no significant difference in the mean minutes spent on additional activities of varying intensity (very light, light, moderate and heavy) over the course of the 5-week study period, across the four cohorts (Addendum 17).

There was a significant difference (p≤0.01; one-way ANOVA test) in the mean total steps completed (i.e. the sum of the baseline daily physical activity and the additional steps prescribed to the Step and Step & RTEC cohorts) over the 5-week study period between the four cohorts (Figure 3.1). The mean baseline total steps completed was 95 484 (SD 28 101; CI:90 383-100 586) steps. The Step (mean=107 845; SD 31 251; CI:95 957-119 732) and Step & RTEC (mean=108 793; SD 26 285; CI:97 943-119 643) cohorts (cohorts with prescribed stepping intervention) both completed significantly more mean total steps than the Control (mean=83 501; SD 22 302; CI:75 321-91 682) and RTEC (mean=86 082; SD 23 367; CI:77 929-94 235) cohorts (cohorts with no prescribed stepping intervention). Furthermore, there was no significant difference (p=1.0; Bonferroni test) in the mean total steps completed between the Step and Step & RTEC cohorts (the two cohorts where the stepping intervention was prescribed) (Figure 3.1).

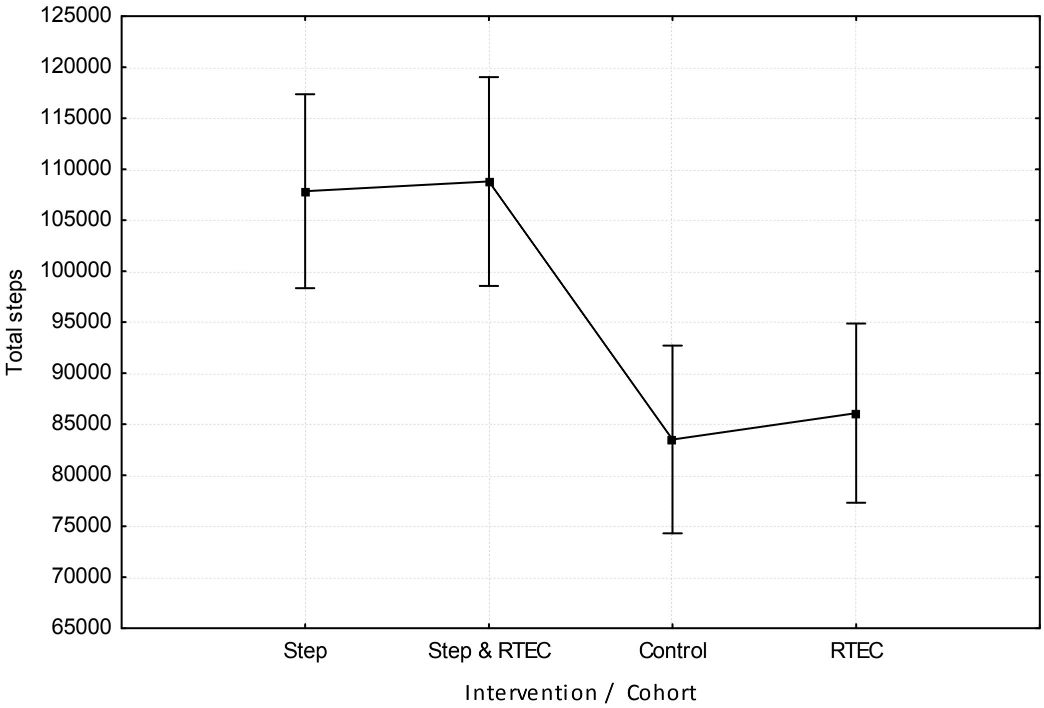


Figure 3.1: Mean total steps completed over the 5-week study period by each of the four cohorts

The mean days on which these extra steps (i.e. the regular increased physical activity) were completed was 14.07 (SD 0.87) and 11.52 (SD 1.13) days by the Step and Step & RTEC cohorts respectively, and no significant difference was found between these two cohorts (Addendum 17).

3.2.2 Comparison of Variables of Physical Activity between the Participants of the Various BMI Classifications

When the participants were classified as 'obese', 'overweight', and 'normal', based on their final BMI (using final heights and weights), there was no significant difference in the mean daily steps, the mean total steps, the mean baseline days on which participants engaged in additional activities, and the mean minutes spent on additional activities of varying intensity (very light, light, moderate and heavy) between the participants of the various classifications (Addendum 18).

3.2.3 Comparison of Variables of Physical Activity between the Male and Female Participants

When the participants were classified according to gender, there were no significant differences found for the following variables of physical activity (mean total steps, mean days of additional activities, and mean minutes of additional activity of very light, light, moderate and heavy intensity) over the 5-week study period between the male and female participants (Addendum 19).

There was however a significant difference (p=0.01; pooled t-test) in the mean baseline daily activity (i.e. the mean daily steps recorded during each school day over the course of the 5-week study period) between the male and female participants of the study population (Figure 3.2), such that the male participants completed significantly more mean daily steps (mean=90401; SD 22911; CI:82763-98040) than the female participants (mean=79375; SD 21705; CI:74606-84144).

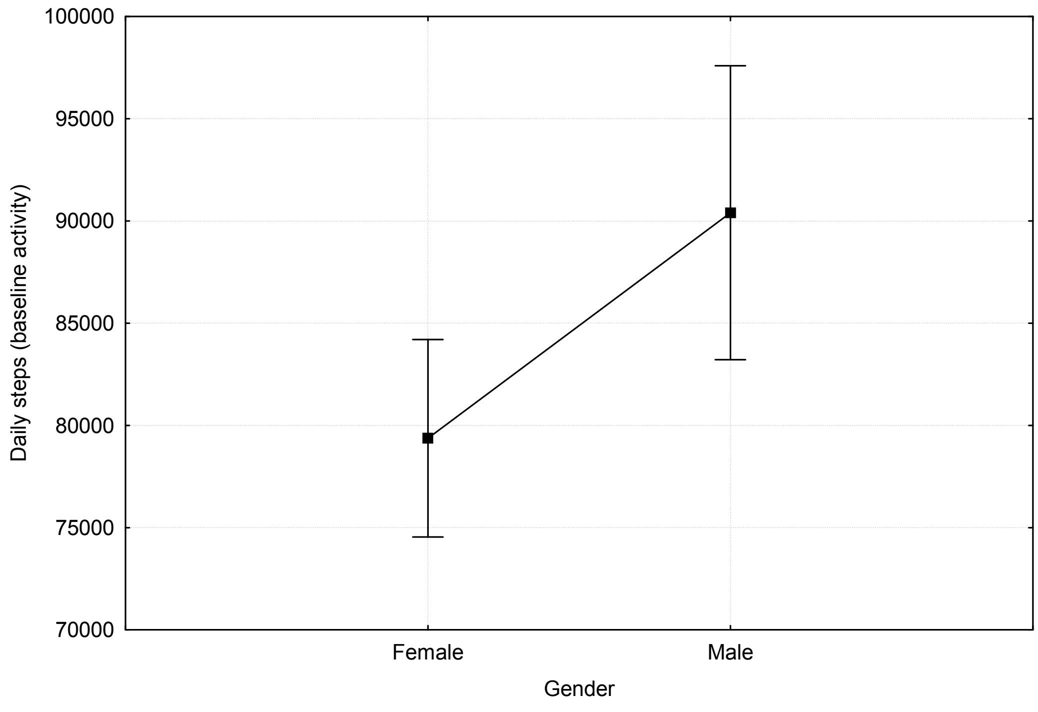


Figure 3.2: Mean baseline daily activity (daily steps) completed over the 5-week study period by male and female participants

3.3 RTEC CONSUMPTION

3.3.1 Comparison of Variables of RTEC Consumption between the Cohorts

The mean baseline days on which breakfast (regardless of nature) was consumed by participants over the 5-week study period was 22.56 (SD 3.69) days and there was no significant difference across the four cohorts (Addendum 20). The mean baseline servings of RTEC snacks consumed for breakfast over the 5-week study period was 0.66 (SD 1.67) servings and there was also no significant difference across the four cohorts (Addendum 20).

The mean baseline servings of RTEC consumed for breakfast over the 5-week study period was 18.56 (SD 8.73; CI: 16.97-20.14) servings. A significant difference ($p<0.01$; Kruskal-Wallis test) was found between RTEC and Control cohorts only (Figure 3.3), such that the RTEC cohort (mean=21.00; SD 5.58; CI:19.06-22.95) consumed a significantly greater mean number of servings of RTEC for breakfast when compared to the Control cohort (mean=14.96; SD 9.41; CI:11.51-18.42).

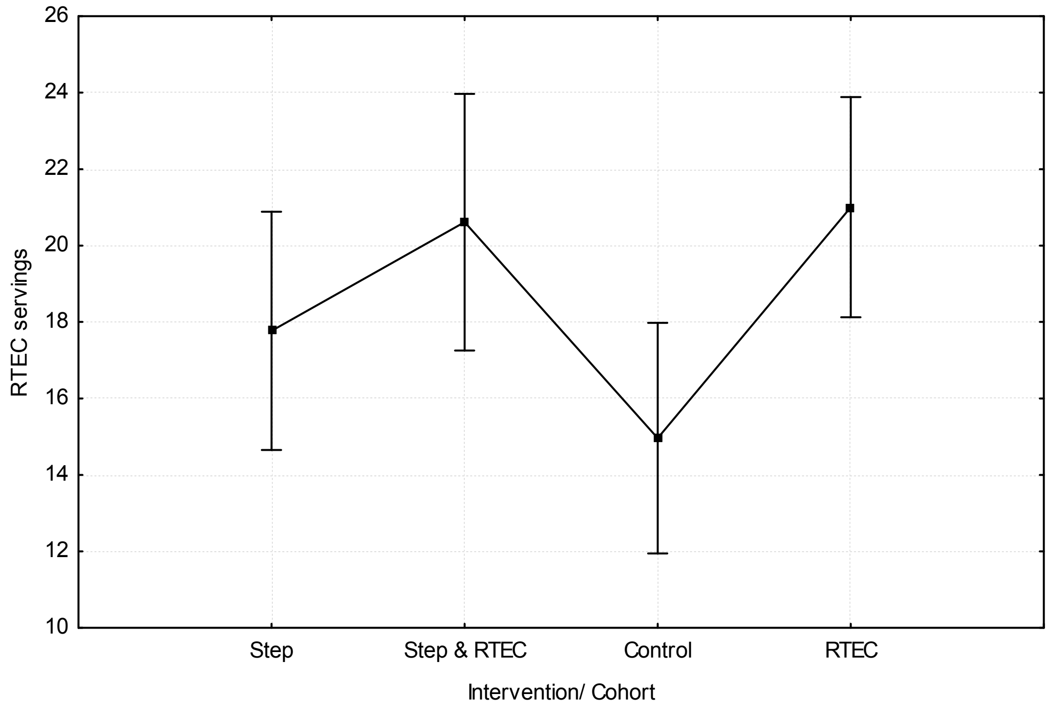


Figure 3.3: Mean servings of RTEC consumed for breakfast over the 5-week study period by each of the four cohorts

The mean baseline days on which an afternoon snack (regardless of nature) was consumed over the 5-week study period was 16.07 (SD 8.14; CI: 14.59-17.55) days. There was a significant difference ($p=<0.01$; one-way ANOVA test) between both the RTEC intervention cohorts (Step & RTEC and RTEC cohorts) and each of the non-RTEC intervention cohorts (Control and Step cohorts) (Figure 3.4), such that the Step & RTEC (mean=19.16; SD 6.17; CI:16.61-21.71) and RTEC (mean=19.88; SD 6.87;

CI:17.48-22.28) cohorts consumed afternoon snacks on significantly more days than the Control (mean=14.19; SD 7.71; CI: 11.36-17.02) and Step (mean=10.93; SD 8.36; CI:7.75-14.11) cohorts.

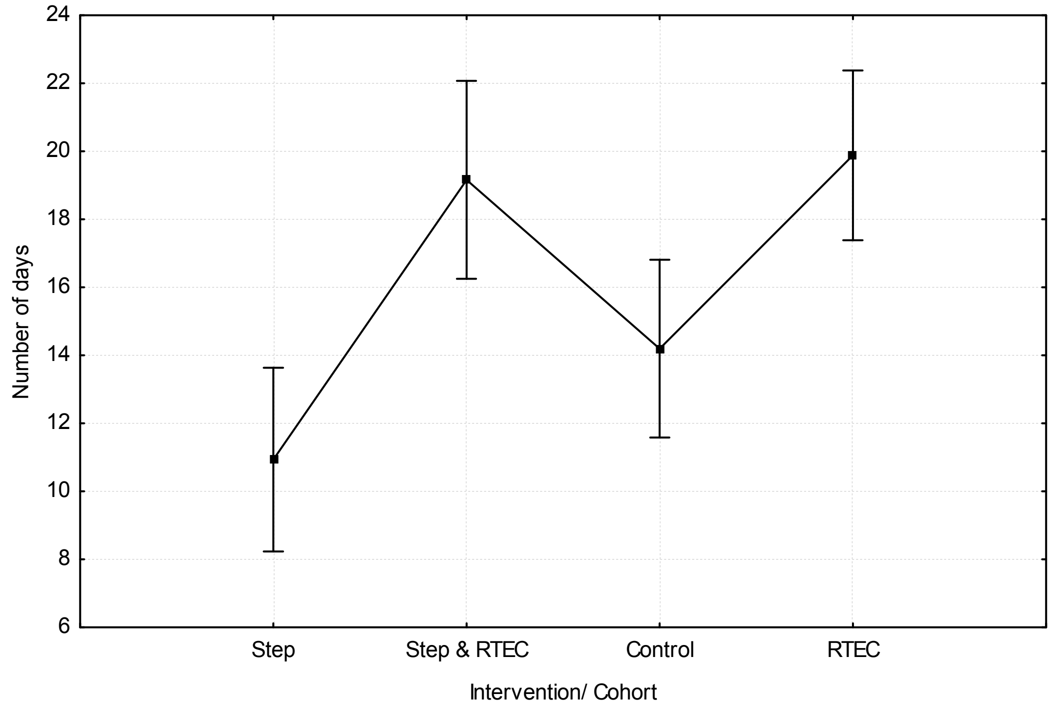


Figure 3.4: **Mean days on which an afternoon snack (regardless of nature) was consumed over the 5-week study period by each of the four cohorts**

The mean baseline servings of RTEC consumed as an afternoon snack over the 5-week study period was 0.62 (SD 1.89; CI:0.28-0.97) servings, and a significant difference (p<0.01; Kruskal-Wallis test) was found between the RTEC and Control cohorts (Figure 3.5), such that the Control cohort (mean= 1.37; SD 2.73; CI:0.37-2.38) showed a significantly higher mean intake of RTEC servings as an afternoon snack as compared to the RTEC cohort (mean=0.12; SD 0.33; CI:0.00-0.23).

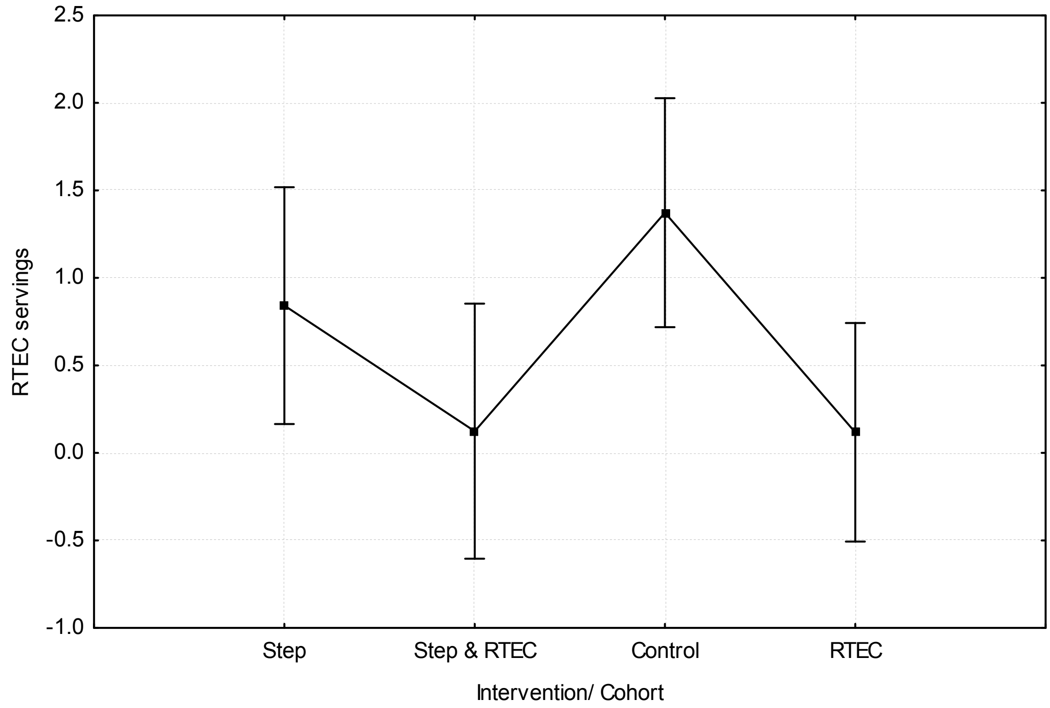


Figure 3.5: Mean RTEC servings consumed as an afternoon snack over the 5-week study period by each of the four cohorts

The mean baseline servings of RTEC snacks consumed as an afternoon snack over the 5-week study period was 8.28 (SD 9.30; CI:6.59-9.97) servings, and a significant difference (p≤0.01; Kruskal-Wallis test) was found between both the RTEC intervention cohorts (Step & RTEC and RTEC cohorts) and each of the non-RTEC intervention cohorts (Control and Step cohorts) (Figure 3.6), such that the Step & RTEC (mean=14.32; SD 7.95; CI:11.04-17.60) and RTEC (mean=16.06; SD 8.82; CI:12.98-19.14) cohorts consumed significantly more mean servings of RTEC snacks as afternoon snacks when compared to the Control (mean=1.13; SD 1.69; CI: 0.51-1.75) and Step (mean=1.59; SD 2.50; CI:0.64-2.54) cohorts.

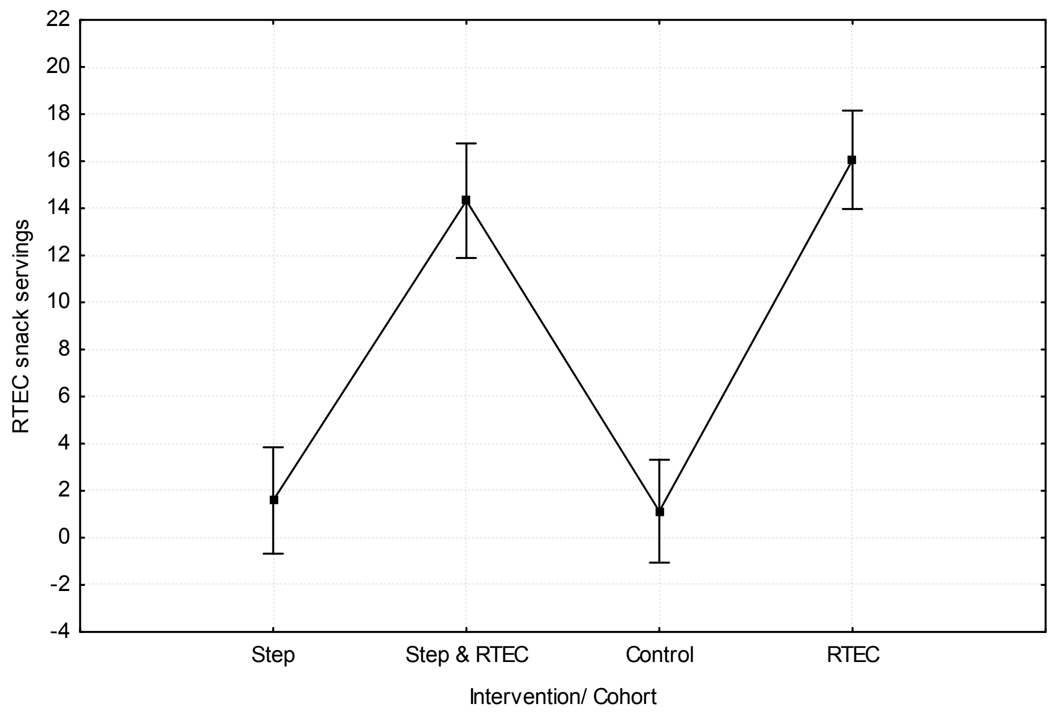


Figure 3.6: Mean RTEC snack servings consumed as an afternoon snack over the 5-week study period by each of the four cohorts

The mean baseline servings of RTEC consumed at times other than at breakfast or as an afternoon snack, over the course of the 5-week study period was 0.38 (SD 1.22) servings, and there was no significant difference across the four cohorts (Addendum 20). There was also no significant difference in the mean servings of RTEC across the four cohorts, when investigated separately according to the other various mealtime classifications of morning snack, lunch, dinner and evening snack (Addendum 20).

The mean baseline servings of RTEC snacks consumed at times other than at breakfast or as an afternoon snack, over the course of the 5-week study period was 1.66 (SD 3.85) servings, and there was no significant difference across the four cohorts (Addendum 20). There was also no significant difference in the mean servings of RTEC snacks across the four cohorts, when investigated separately according to the other various mealtime classifications of morning snack, lunch and evening snack (Addendum 20).

The mean baseline servings of RTEC snacks consumed at dinner over the 5-week study period was 0.05 (SD 0.29; CI:-0.00-0.10) servings, and a significant difference ($p=0.03$; one-way ANOVA test) was found between the Step & RTEC cohort and the RTEC cohort (Figure 3.7), such that the Step & RTEC cohort (mean=0.20; SD 0.58; CI:-0.04-0.44) consumed a significantly greater mean number of RTEC snack servings at dinner than the RTEC (mean=0; SD 0) cohort.

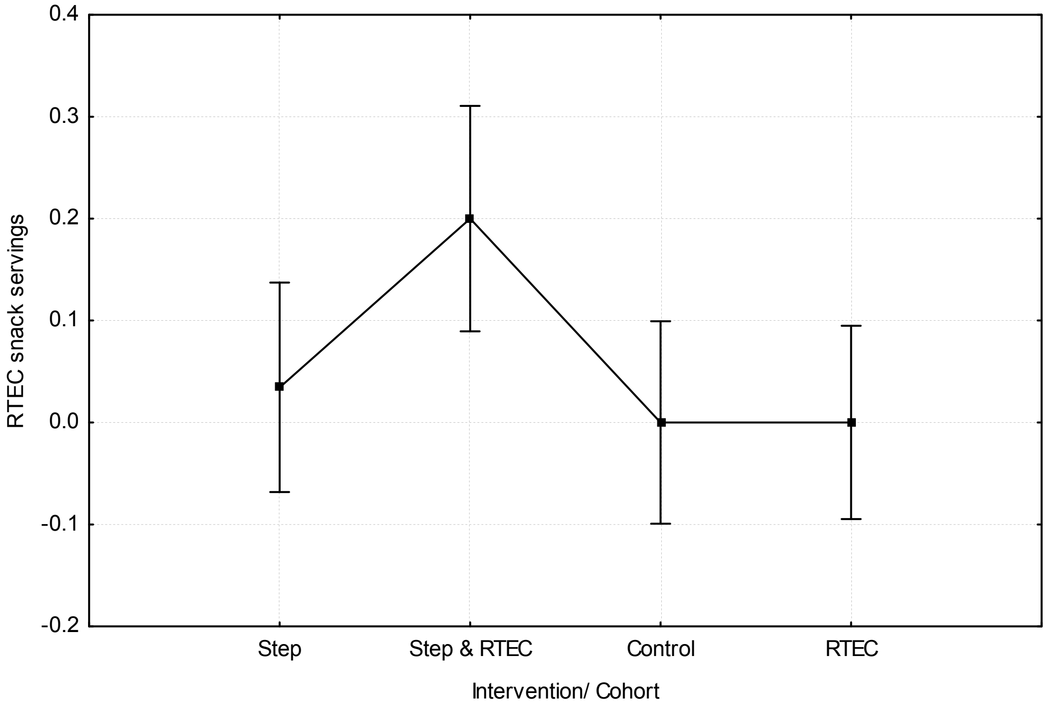


Figure 3.7: Mean RTEC snack servings consumed at dinner over the 5-week study period by each of the four cohorts

In summary, the mean baseline total RTEC servings consumed over the 5-week study period was 19.56 (SD 9.06) servings, and no significant difference was found across the four cohorts (Addendum 20), while the mean baseline total RTEC snack servings consumed over the 5-week study period was 10.60 (SD 10.05; CI:8.77-12.42) servings, and a significant difference ($p<0.01$; Kruskal-Wallis test) was found between the two RTEC intervention cohorts (RTEC and Step & RTEC cohorts) and the two non-RTEC intervention cohorts (Control and Step cohorts) (Figure 3.8), such that the RTEC (mean=18.97; SD 7.76; CI:16.26-21.68) and Step & RTEC (mean=17.04; SD 8.34; CI:13.60-20.48) cohorts consumed a significantly greater mean total RTEC snack servings than the Control (mean=3.29; SD 5.90; CI:1.13-5.45) and Step (mean=3.03; SD 4.12; CI:1.47-4.60) cohorts.

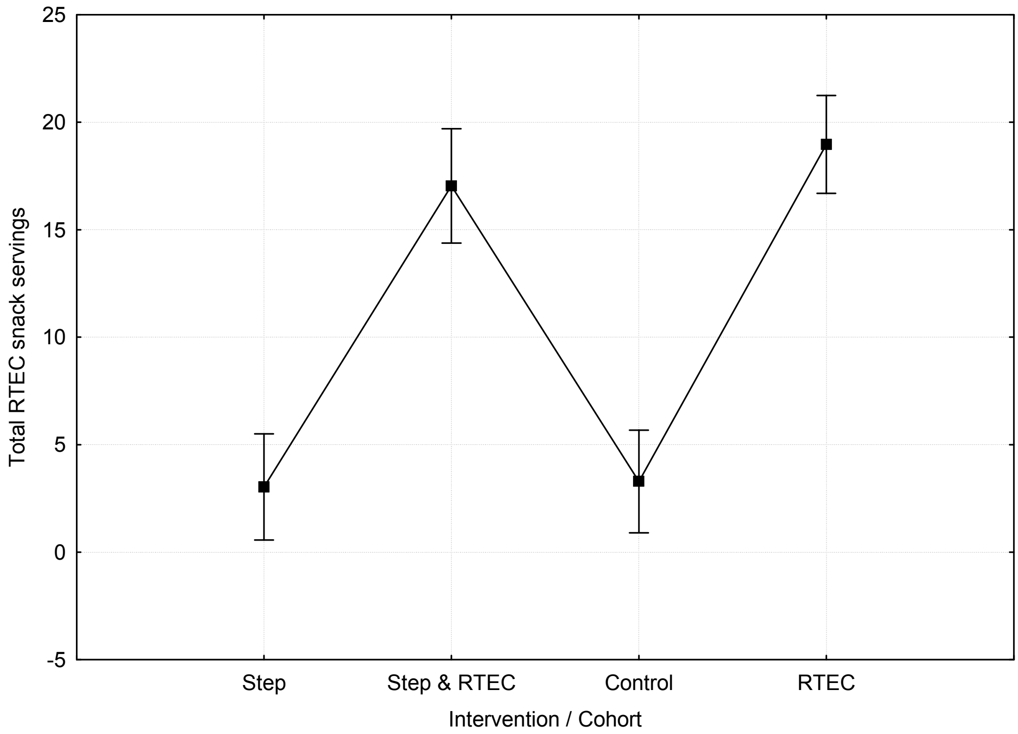


Figure 3.8: Mean total RTEC snack servings consumed over the 5-week study period by each of the four cohorts

3.3.2 Comparison of Variables of RTEC Consumption between the Participants of the Various BMI Classifications

When the participants were classified as 'obese', 'overweight', and 'normal', based on their final BMI (using final heights and weights), no significant differences in the various variables of RTEC consumption were found over the course of the 5-week study period, between the participants of the various classifications (Addendum 21).

3.3.3 Comparison of Variables of RTEC Consumption between the Male and Female Participants

When the participants were classified according to gender, there were no significant differences found for any of the consumption variables over the 5-week study period between the male and female participants (Addendum 22).

3.4 ANTHROPOMETRIC VARIABLES

3.4.1 Initial Anthropometric Variables

At the start of the 5-week study period, most of the participants were classified as having normal weight (Figure 3.9), while 21 % were classified as being overweight, and 10 % as obese.

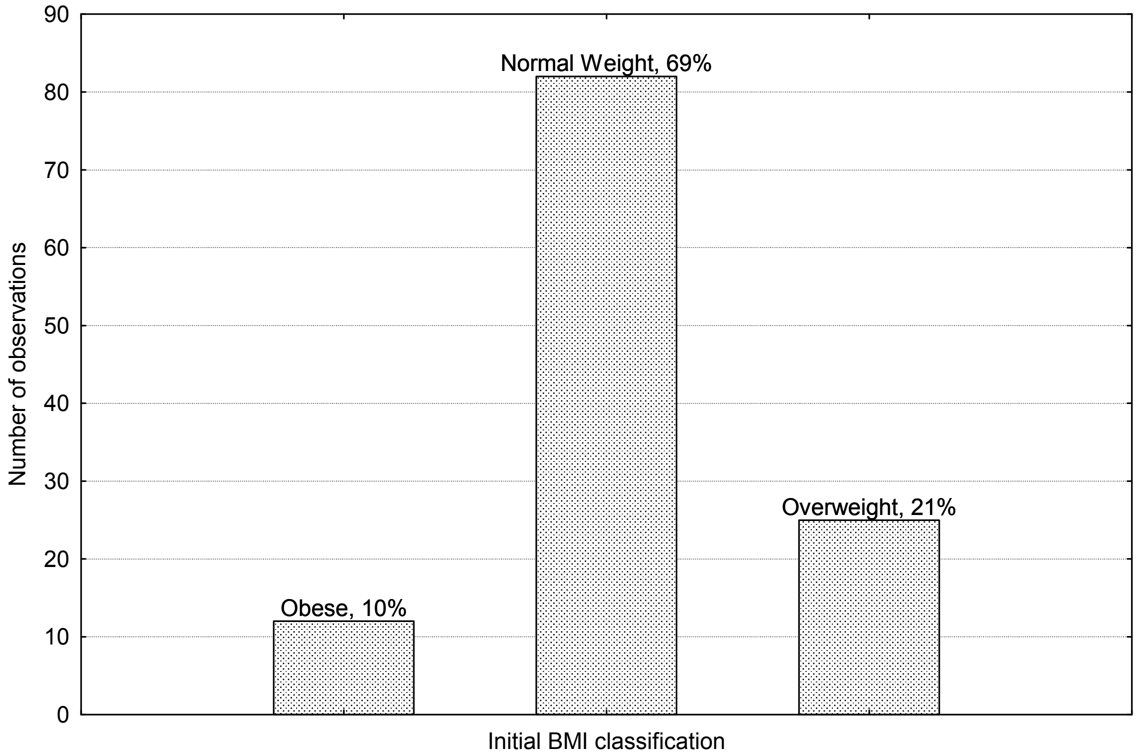


Figure 3.9: Frequency of initial BMI classifications across the study population

The mean baseline body weight at the start of the 5-week study period was 47.24 kg (SD 12.03), and there was no significant difference across the four cohorts (Addendum 23). The mean baseline percentage body fat at the start of the 5-week study period was 23.66 % (SD 8.71), and there was also no significant difference across the four cohorts (Addendum 23).

A significant difference ($p \leq 0.01$; pooled t-test) was however evident in the mean initial percentage body fat between the male and female participants (Figure 3.10), such that the females (mean=25.58; SD 8.09; CI: 23.80-27.36) showed a significantly higher mean initial percentage body fat than the males (mean=19.39; SD 8.61; CI:16.53-22.26).

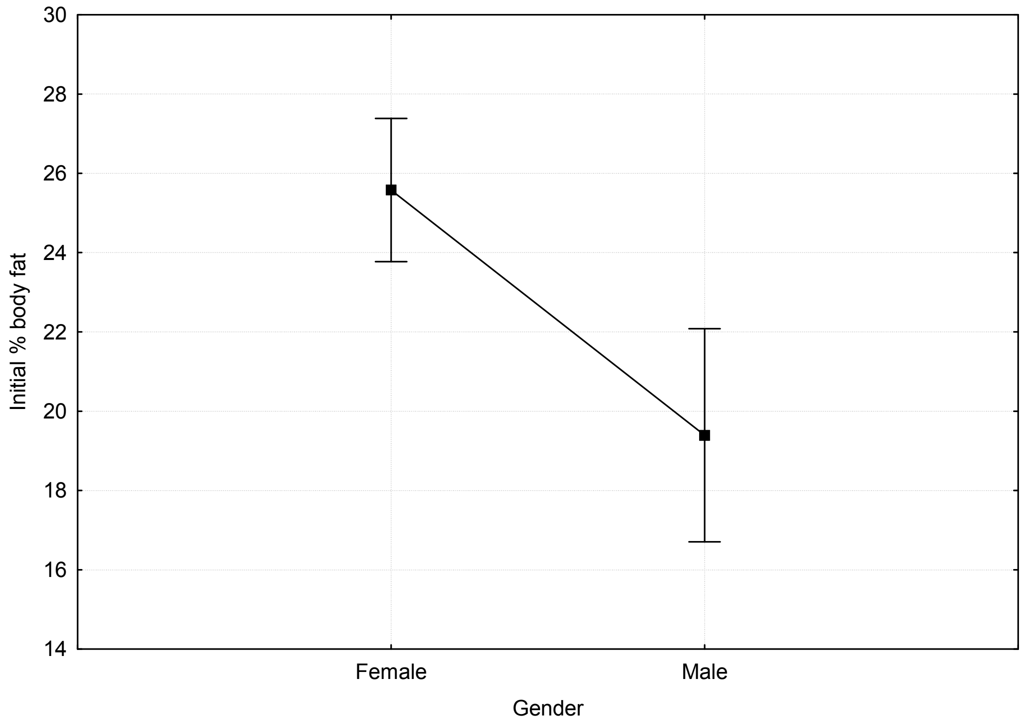


Figure 3.10: Mean initial percentage body fat of male and female participants

3.4.2 Final Anthropometric Variables

At the end of the study most of the participants were still classified as having a normal weight (Figure 3.11), while 20% were classified as overweight and 9% as obese.

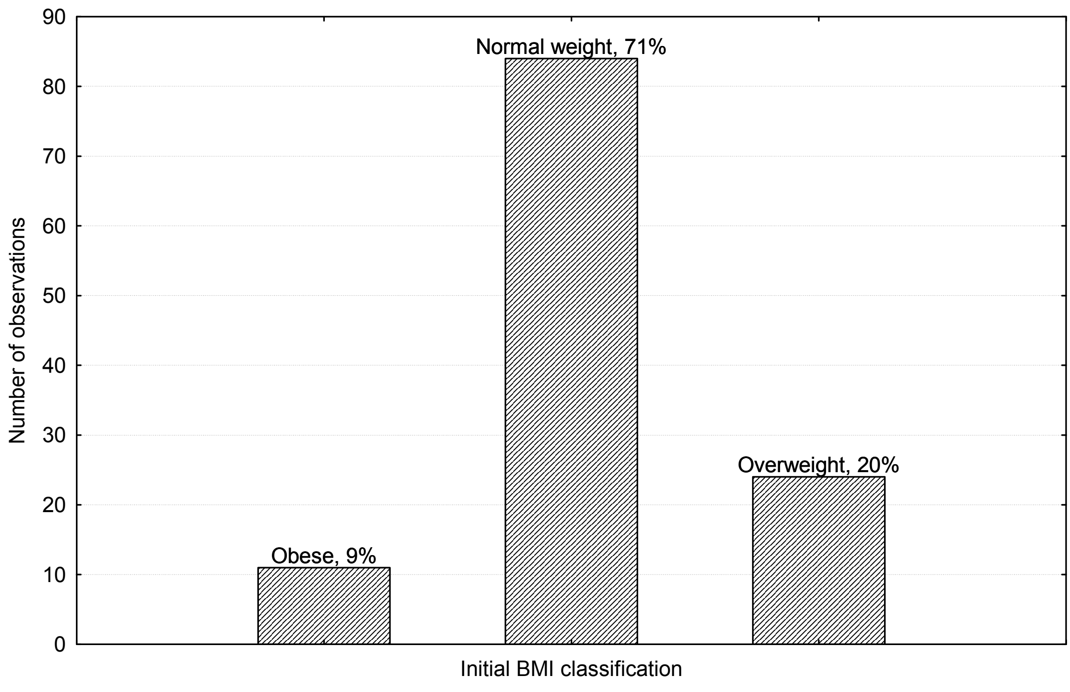


Figure 3.11: Frequency of final BMI classifications across the study population

The frequency of the various final BMI classifications across the four cohorts also indicates that in all four cohorts, the majority of the participants were normal weight (Figure 3.12).

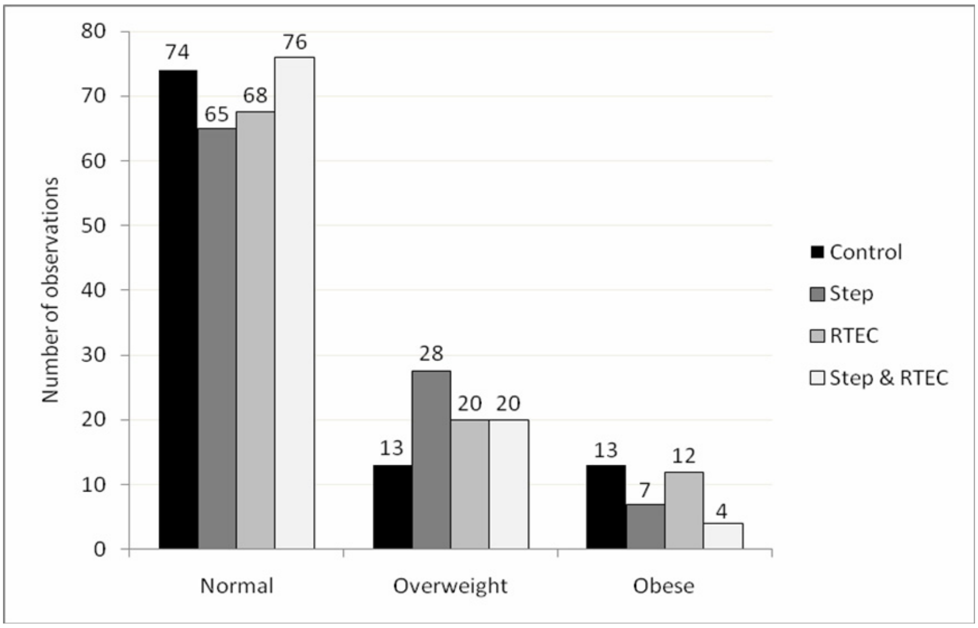


Figure 3.12: Frequency of final BMI classifications across the four cohorts of the study population

The racial distribution across the final BMI classifications of the study population (Figure 3.13) indicates that the majority of obese children were black and the majority of overweight and normal weight children were white.

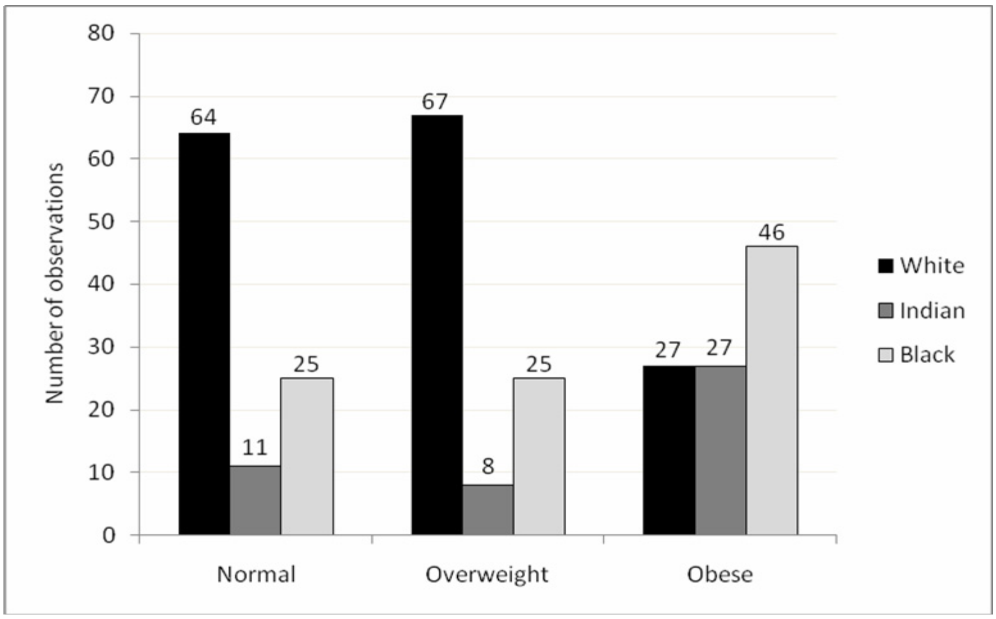


Figure 3.13: Racial distribution across the final BMI classifications of the study population

A significant difference (p≤0.01; pooled t-test) in the mean percentage body fat (as measured at the end of the 5-week study) remained between the male and female participants (Figure 3.14), such that the males maintained a significantly lower final mean percentage body fat (mean=18.74; SD 8.13; CI: 16.03-21.45) than the females (mean=25.55; SD 7.90; CI:23.81-27.28).

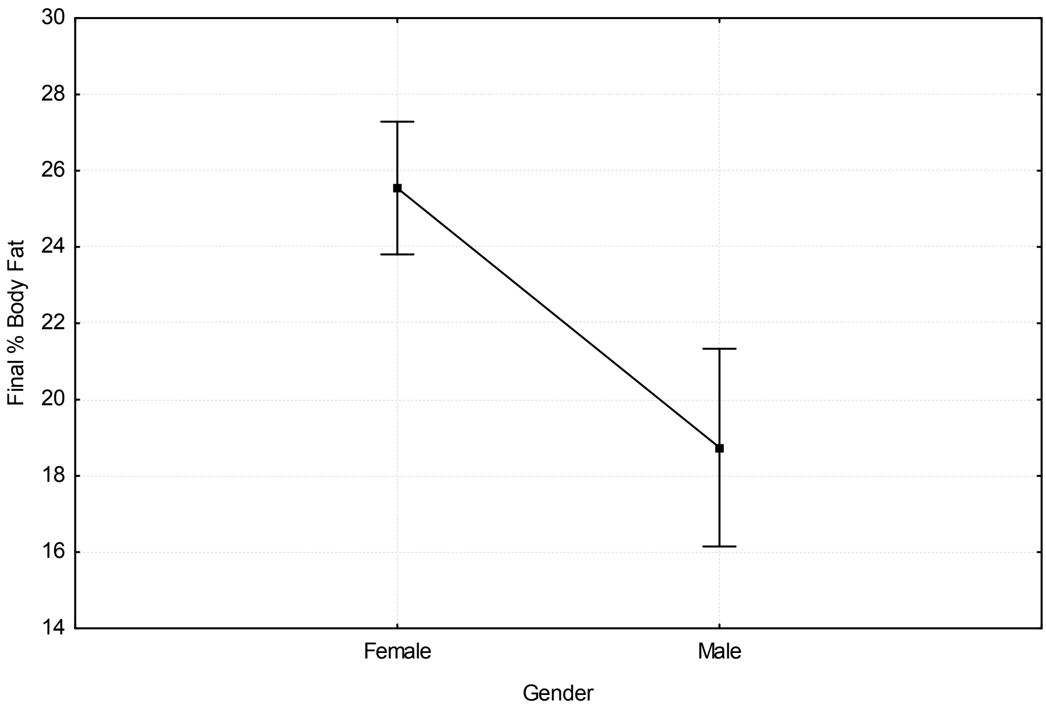


Figure 3.14: Mean final percentage body fat of female and male participants

3.4.3 Mean Changes in the Various Anthropometric Variables over the 5-week Study Period

At the end of the 5-week study period, the mean weight change achieved was -0.07 kg (SD 0.79), the mean baseline change in BMI achieved was -0.15 kg/m^2 (SD 0.40), the mean baseline change in percentage body fat achieved was -0.23 % (SD 1.09), and the mean baseline change in kilograms of body fat achieved was -0.15 kg (SD 0.66). There was no significant difference in any of the above mentioned anthropometric variables across the four cohorts (Addendum 24).

When the participants were classified as 'obese', 'overweight', and 'normal', based on their final BMI (using final heights and weights), there was no significant difference in the mean change in weight over the 5-week study period between participants of the various BMI classifications (Addendum 25).

There was however, a significant difference in the mean change in percentage body fat (p≤0.01; one-way ANOVA test) over the 5-week study period between the participants of the various final BMI classifications (Figure 3.15), such that the participants with a final BMI classification of obese showed a significantly greater mean reduction in percentage body fat (mean=-1.17; SD 1.42; CI: -2.13—0.22) than the participants with a final BMI classification of normal (mean=-0.13; SD 0.94; CI:-0.33-0.08) or overweight (mean=-0.14; SD 1.26; CI: -0.67-0.40).

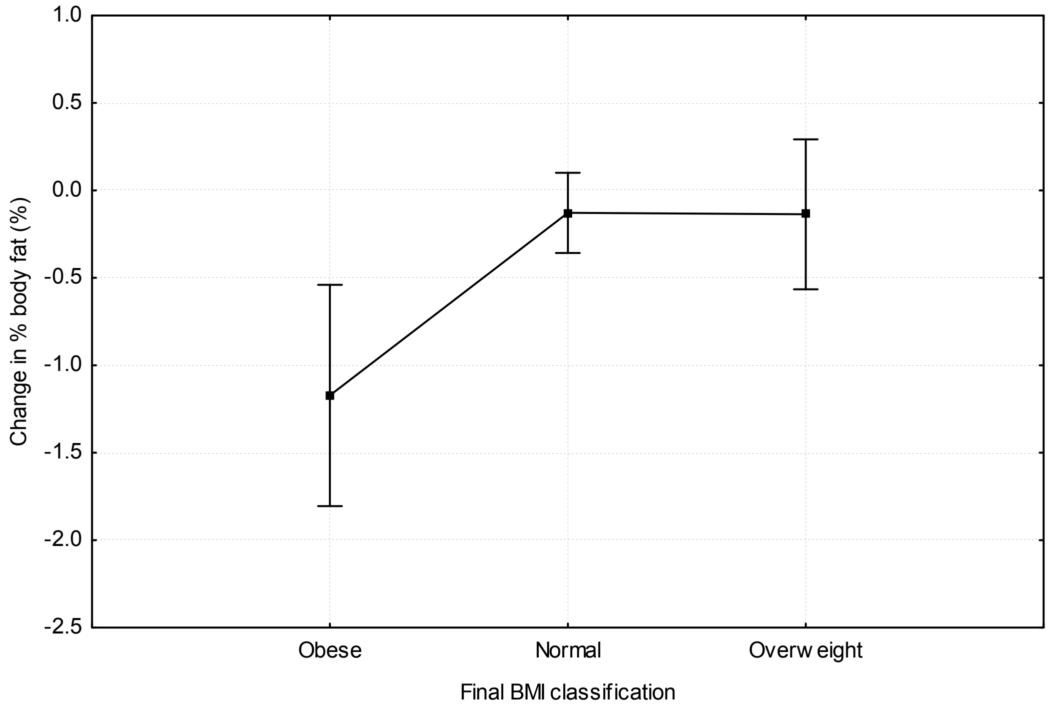


Figure 3.15: Mean change in percentage body fat of the various final BMI classifications of study population

Similarly, there was also a significant difference in the mean change in kilograms of body fat ($p \leq 0.01$; one-way ANOVA) over the 5-week study period between the participants of the various final BMI classifications (Figure 3.16), such that the participants with a final BMI classification of obese showed a significantly greater mean reduction in kilograms of body fat (mean=-0.85; SD 1.05; CI:-1.55- -0.15) than the participants with a final BMI classification of normal ($p<0.00$ (Bootstrap test); mean -0.07; SD 0.47; CI:-0.18-0.03) or overweight ($p<0.04$ (Bootstrap test); mean=-0.11; SD 0.83; CI:-0.46-0.23).

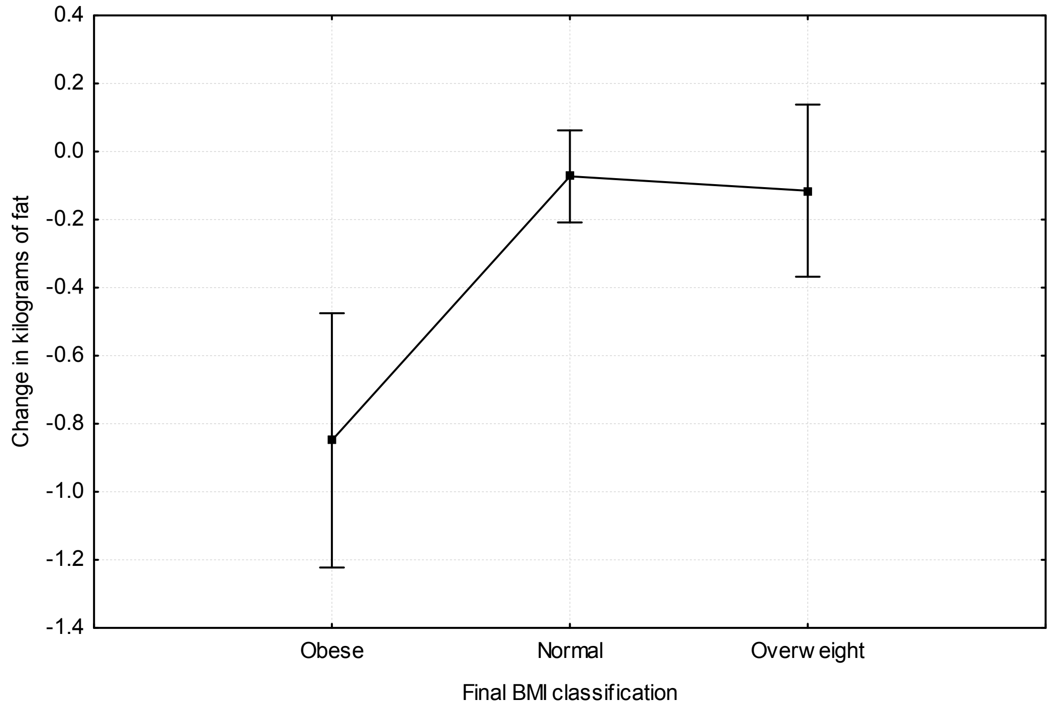


Figure 3.16: Mean change in kilograms of body fat of the various BMI classifications of study population

When the participants were classified according to gender, there was no significant difference found in the mean change in weight and mean change in BMI over the 5-week study period between the male and female participants (Addendum 26).

There was however a significant difference in the mean change in percentage body fat ($p \leq 0.01$; pooled t-test) over the 5-week study period between the male and female participants of the study population (Figure 3.17), such that the male participants showed a significantly greater mean decrease in percentage body fat (mean=-0.65; SD 1.09; CI:-1.02- -0.29) than the female participants (mean=-0.03; SD 1.05; CI:-0.26-0.20).

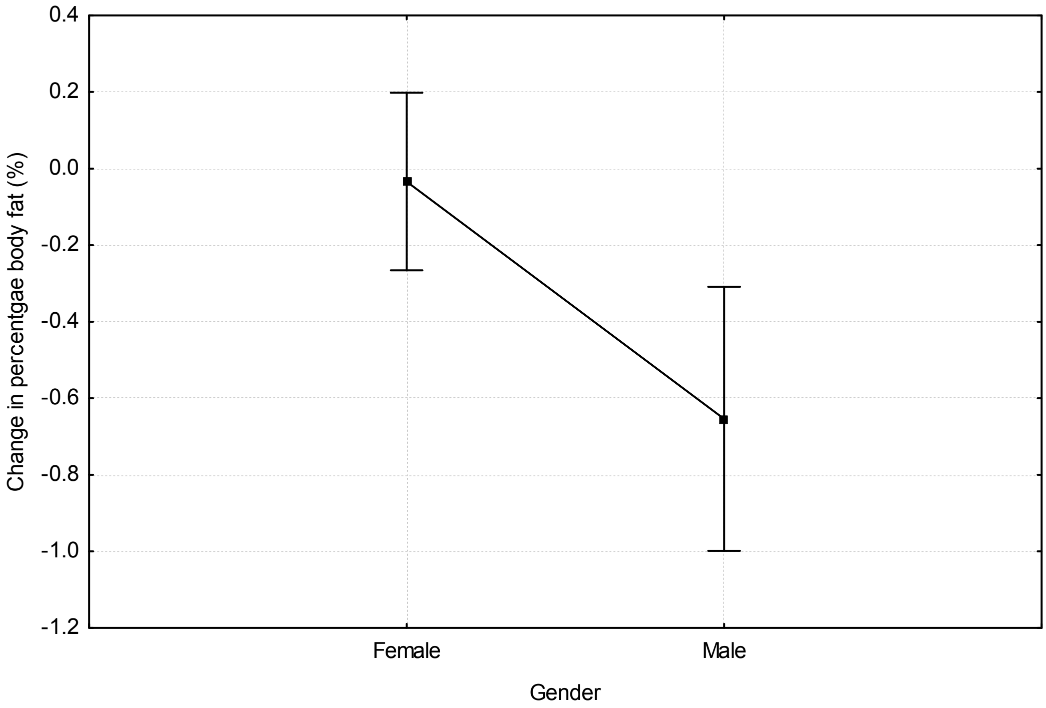


Figure 3.17: Mean change in percentage body fat of male and female participants in study population

Similarly there was a significant difference in the mean change in kilograms of body fat (p=<0.01; pooled t-test) over the 5-week study period between the male and female participants of the study population (Figure 3.18), such that the male participants showed a significantly greater mean decrease in kilograms body fat (mean=-0.41; SD 0.70; CI:-0.64- -0.17) than the female participants (mean=-0.04; SD0.61; CI:-0.17-0.10).

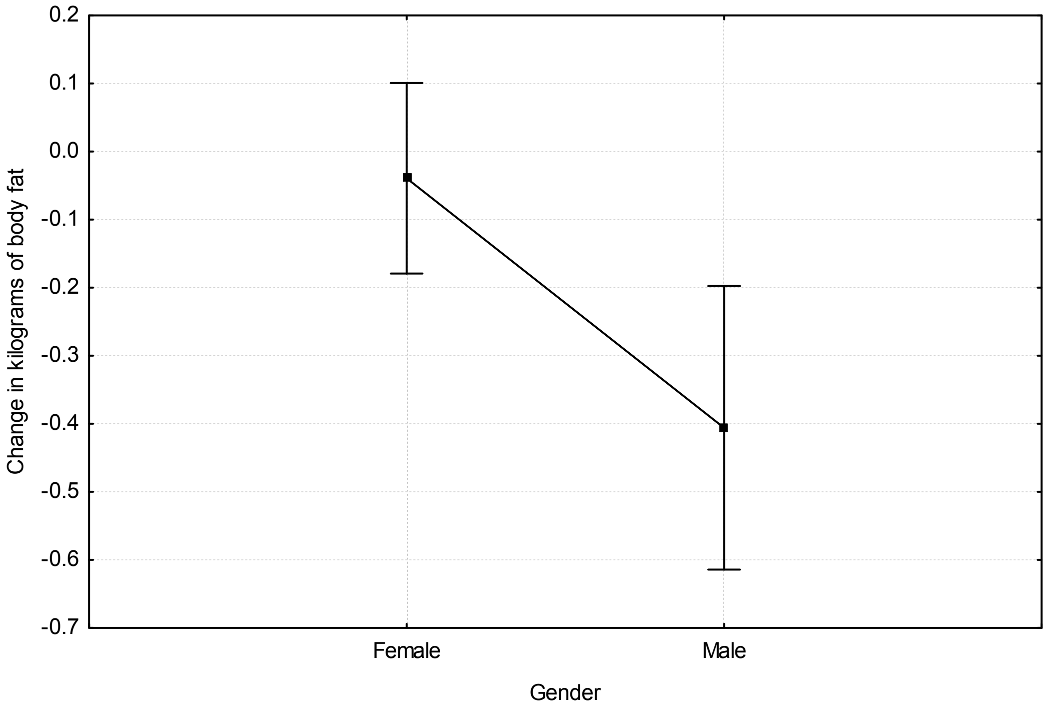


Figure 3.18: Mean change in kilograms of body fat of male and female participants in study population

3.4.4 Correlations between the Various Variables of Anthropometry, Physical Activity and RTEC Consumption

3.4.4.1 Correlations between the various variables of anthropometry and the various variables of physical activity

There was no significant correlation (p=0.35; r=0.09) found between the final weight of the participants and the total steps completed over the course of the 5-week study period. There were also no significant correlations found between the final weight of the participants and the number of days on which the participants engaged in additional activities (p=0.97; r=0.00), the minutes spent engaging in very light intensity additional activity (p=0.85; r=0.02), the minutes spent engaging in light intensity additional activity (p=1.00; r=0.00), the minutes spent engaging in moderate intensity additional activity (p=0.38; r=-0.08), and the minutes spent engaging in heavy intensity additional activity (p=0.42; r=-0.07).

At the end of the 5-week study period, there was no significant correlation (p=0.89; r=-0.01) between the participants' change in weight and the total steps completed over the course of the study. There was however a significant correlation (p=0.02; r=-0.21) between the participants' change in percentage body fat and the total steps completed over the course of the study (Figure 3.19), such that change in percentage body fat was found to be negatively correlated with the total steps completed i.e. a greater decrease in percentage body fat was noted with the increasing number of total steps completed.

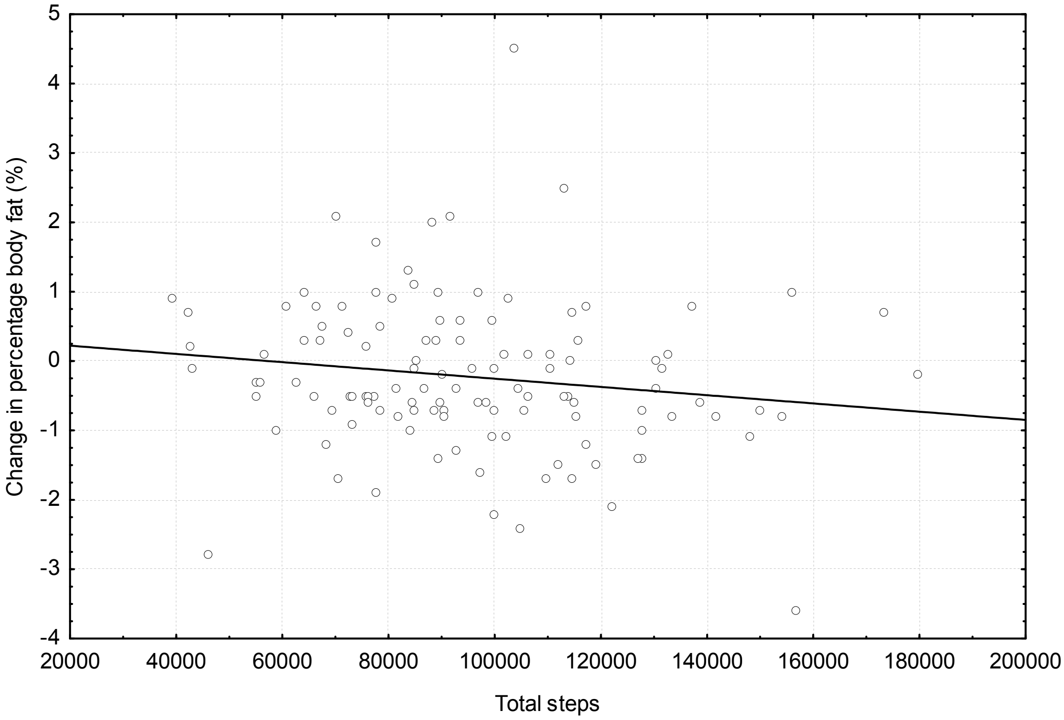


Figure 3.19: Correlation between participants' change in percentage body fat and the total steps completed over the 5-week study period

Furthermore, there was no significant correlation (p=0.31; r=0.09) between the participants' change in percentage body fat and the number of days on which participants engaged in additional activities. There was also no significant correlation between the participants' change in percentage body fat and the minutes spent participating in very light intensity (p=0.77; r=0.03), light intensity (p=0.25; r=0.11), and moderate intensity (p=0.40; r=-0.08) additional activities, while a significant correlation (p=0.03; r=0.20) was found between the participants' change in percentage body fat and the minutes spent participating in heavy intensity additional activities (Figure 3.20), such that change in percentage body fat was found to be positively correlated with minutes spent participating in heavy intensity additional activities i.e. an increase in percentage body fat was noted with increasing minutes reported spent participating in heavy intensity exercise.

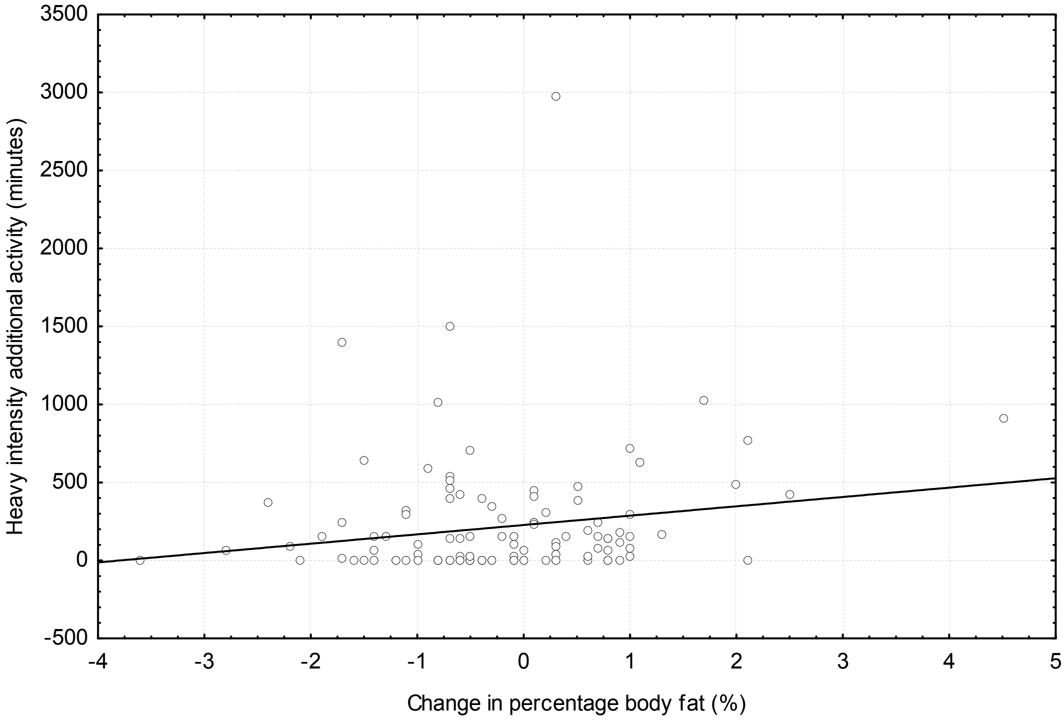


Figure 3.20: Correlation between participants' change in percentage body fat and minutes spent participating in heavy intensity additional activities over the 5-week study period

There was no significant correlation (p=0.07; r=-0.16) between the participants' change in kilograms of body fat and the total steps completed over the course of the study, and no significant correlation (p=0.20; r=0.12) between the participants' change in kilograms of body fat and the number of days on which participants engaged in additional activities. There was also no significant correlation between the participants' change in kilograms of body fat and the minutes spent participating in very light intensity (p=0.92; r=0.01), light intensity (p=0.10; r=0.15), and moderate intensity (p=0.43; r=-0.07) additional activities. There was however a significant correlation (p=0.01; r=0.25) between the participants' change in kilograms of body fat and the minutes spent participating in heavy intensity additional activities (Figure 3.21), such that change in kilograms of body fat was found to be positively correlated with minutes spent participating in heavy intensity additional activities i.e. an increase in kilograms of body fat was noted with increasing minutes reported spent participating in heavy intensity activity.

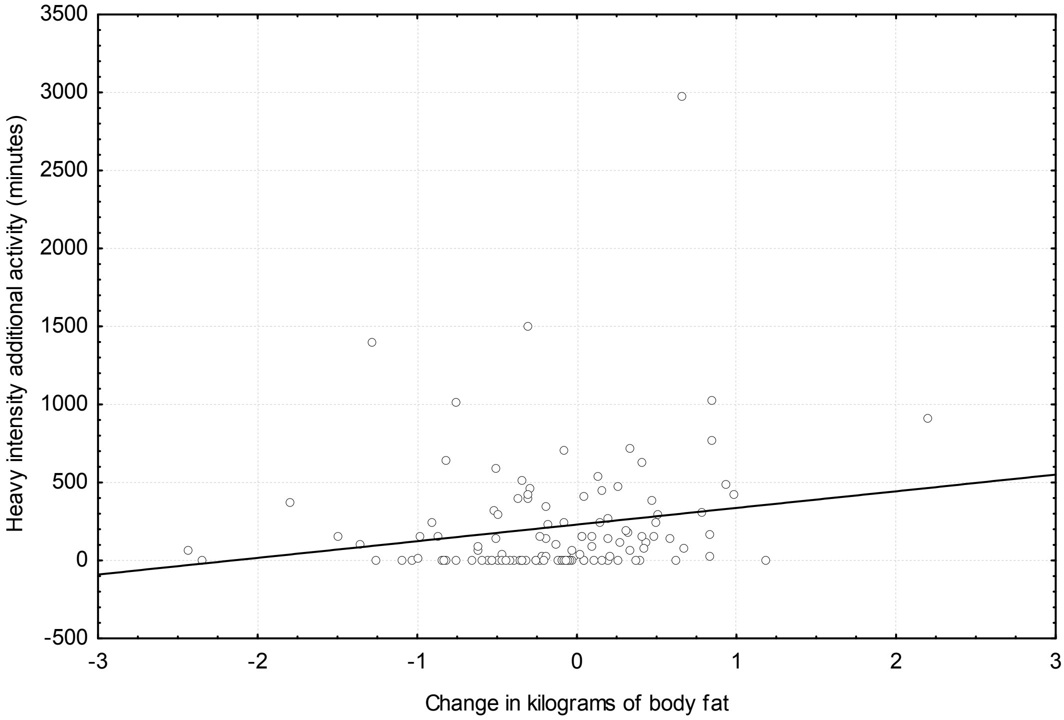


Figure 3.21: Correlation between participants' change in kilograms of body fat and minutes spent participating in heavy intensity additional activities over the 5-week study period

3.4.4.2 Correlations between the various variables of anthropometry and the various variables of RTEC consumption

There was no significant correlation between the participants' final weight at the end of the 5-week study period and the number of days on which breakfast (regardless of type) was consumed (p=0.57; r=0.05), the number of days on which an afternoon snack (regardless of type) was consumed (p=0.78; r=-0.03), the total number of RTEC servings consumed (p=0.53; r=0.06), and the total number of RTEC snack servings consumed (p=0.22; r=0.11).

At the end of the 5-week study period, there was also no significant correlation between the participants' change in weight over the course of the study and the following variables: the number of days on which breakfast (regardless of type) was consumed (p=0.86; r=-0.02), the number of days on which an afternoons snack (regardless of type) was consumed (p=0.87; r=0.02), the servings of RTEC consumed at breakfast (p=0.52; r=-0.06), the servings of RTEC snacks consumed at breakfast (p=0.48; r=-0.06), the servings of RTEC consumed as an afternoon snack (p=0.07; r=0.17), and the servings of RTEC snacks consumed at times other than breakfast or as an afternoon snack (p=0.90; r=-0.01).

There was however a significant correlation (p=0.03; r=-0.20) between the participants' change in weight over the 5-week study period and the servings of RTEC snacks consumed as an afternoon snack (Figure 3.22), such that change in weight was negatively correlated with the servings of RTEC snacks consumed as an afternoon snack.

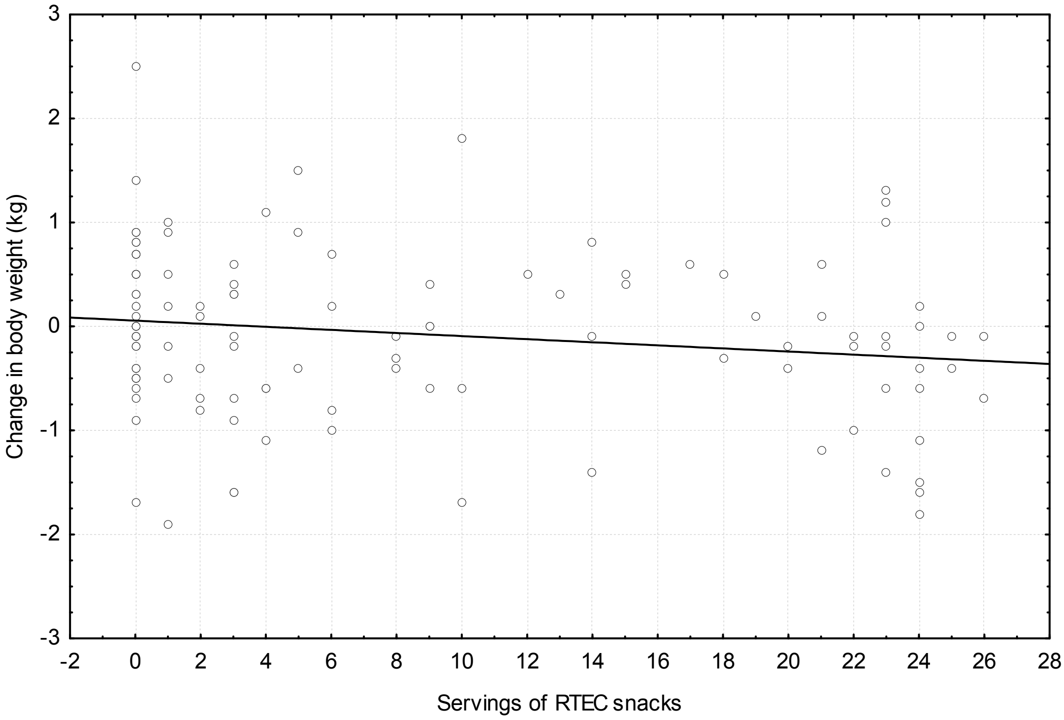


Figure 3.22: Correlation between participants' change in body weight and the servings of Ready-To-Eat cereal (RTEC) snacks consumed as an afternoon snack over the 5-week study period

Furthermore there was a significant correlation (p=0.03; r=0.21) between the participants' change in weight over the 5-week study period and the servings of RTEC consumed at times other than breakfast or as an afternoon snack (Figure 3.23), such that the difference in the participants' weight was positively correlated with the servings of RTEC consumed at times other than breakfast or as an afternoon snack i.e. an increase in weight was noted with an increase in the servings of RTEC consumed at times other than at breakfast or as an afternoon snack.

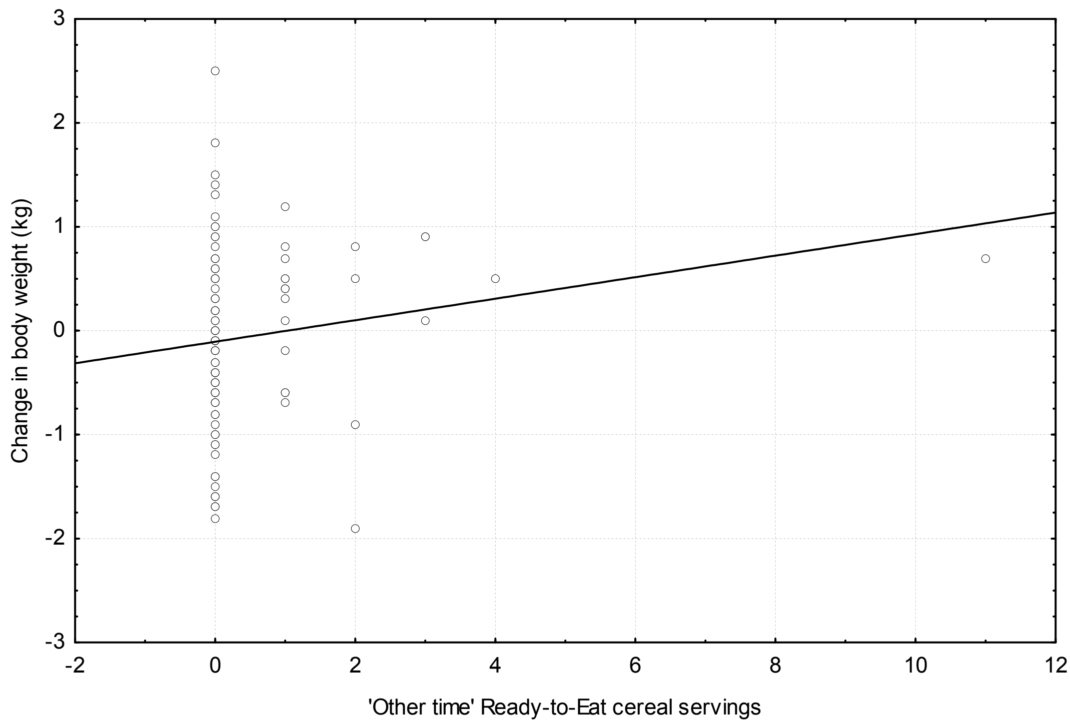


Figure 3.23: Correlation between participants' change in body weight and the servings of Ready-To-Eat cereal (RTEC) consumed at times other than breakfast or as an afternoon snack over the 5-week study period

There was however no significant correlation found between either the total servings of RTEC (p=0.85; r=0.02) or the total servings of RTEC snacks (p=0.10; r=-0.15) consumed over the course of the 5-week study period and the participants' change in body weight.

At the end of the 5-week study period, there was also no significant correlation between the participants' change in percentage body fat over the course of the study and the following variables: the number of days on which breakfast (regardless of type) was consumed (p=0.84; r=-0.02), the number of days on which an afternoons snack (regardless of type) was consumed (p=0.41; r=0.08), the servings of RTEC consumed at breakfast (p=0.68; r=-0.04), the servings of RTEC snacks consumed at breakfast (p=0.29; r=-0.10), the servings of RTEC consumed as an afternoon snack (p=0.13; r=0.14), the servings of RTEC snacks consumed as an afternoon snack (p=0.35; r=-0.09), and the servings of RTEC snacks consumed at times other than breakfast or as an afternoon snack (p=0.27; r=-0.10). There was however a significant correlation (p=0.03; r=0.20) between the participants' change in percentage body fat over the 5-week study period and the servings of RTEC consumed at times other than breakfast or as an afternoon snack (Figure 3.24), such that the participants' change in percentage body fat was positively correlated with the servings of RTEC consumed at times other than breakfast or as an afternoon snack.

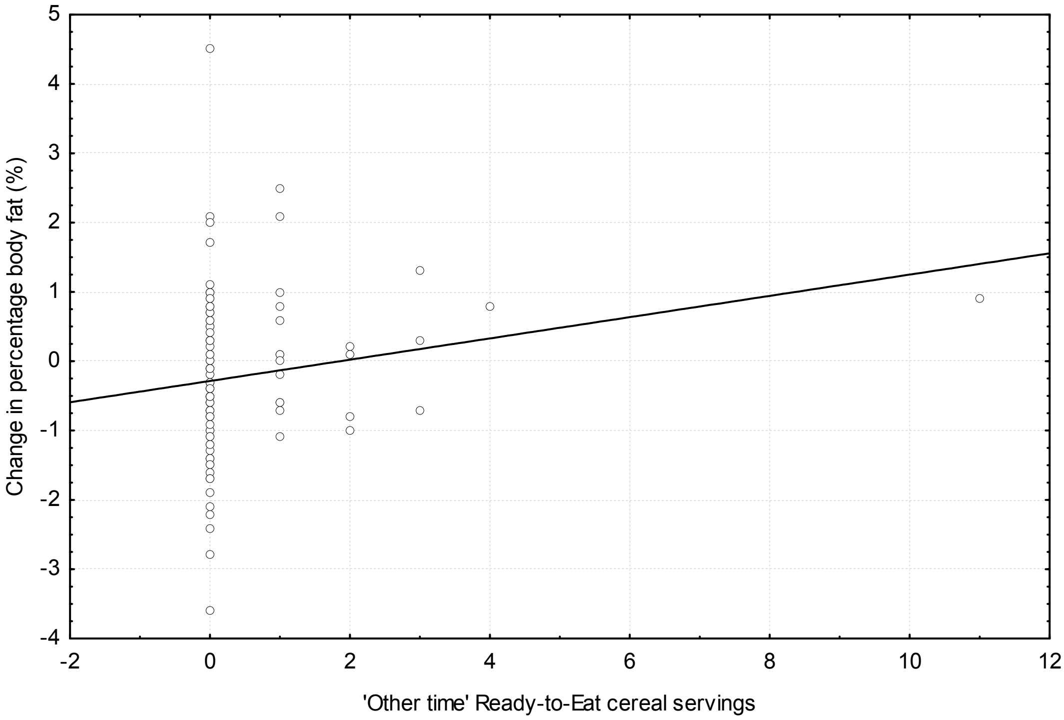


Figure 3.24: Correlation between participants' change in percentage body fat and the servings of Ready-To-Eat cereal (RTEC) consumed at times other than breakfast or as an afternoon snack over the 5-week study period

There was however no significant correlation found between either the total servings of RTEC (p=0.20; r=0.12) or the total servings of RTEC snacks (p=0.26; r=-0.10) consumed over the course of the 5-week study period and the participants' change in percentage body fat.

When the change in the participants' kilograms of body fat over the course of the 5-week study period was investigated, no significant correlations were found with the following variables: the number of days on which breakfast (regardless of type) was consumed (p=0.55; r=-0.06), the number of days on which an afternoons snack (regardless of type) was consumed (p=0.57; r=0.05), the servings of RTEC consumed at breakfast (p=0.99; r=0.00), the servings of RTEC snacks consumed at breakfast (p=-0.06; r=-0.50), the servings of RTEC consumed as an afternoon snack (p=0.08; r=0.16), the servings of RTEC snacks consumed as an afternoon snack (p=0.24; r=-0.11), and the servings of RTEC snacks consumed at times other than breakfast or as an afternoon snack (p=0.55; r=-0.06). There was however a significant correlation (p=0.02; r=0.22) between the participants' change in kilograms of body fat over the 5-week study period and the servings of RTEC consumed at times other than breakfast or as an afternoon snack (Figure 3.25), such that the participants' change in kilograms of body fat was positively correlated with the servings of RTEC consumed at times other than breakfast or as an afternoon snack.

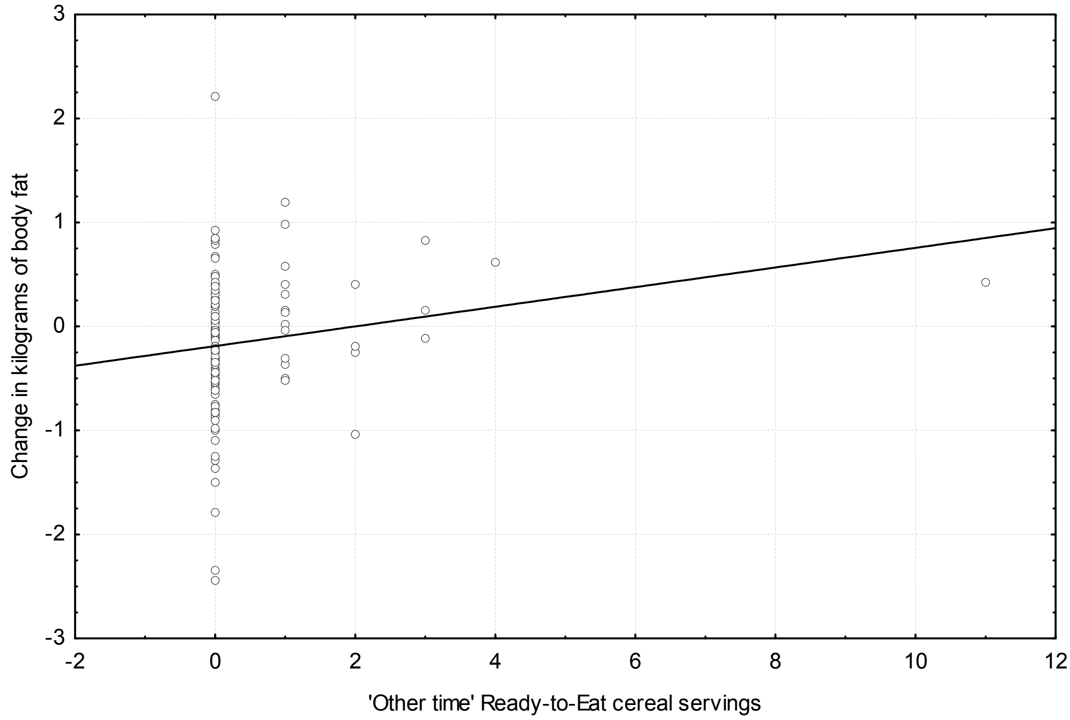


Figure 3.25: Correlation between participants' change in kilograms of body fat and the servings of Ready-To-Eat cereal (RTEC) consumed at times other than breakfast or as an afternoon snack over the 5-week study period

There was however no significant correlation found between either the total servings of RTEC (p=0.31; r=0.09) or the total servings of RTEC snacks (p=0.28; r=-0.10) consumed over the course of the 5-week study period and the participants' change in kilograms of body fat.

CHAPTER 4: DISCUSSION

4.1 PHYSICAL ACTIVITY

Both cohorts to which the additional 'stepping' intervention was prescribed completed significantly more mean total steps than the cohorts to which no additional 'stepping' intervention was prescribed. The Fleurbaix-Laventi-Ville-Santé Study hypothesises that the role of the child in a prevention campaign is to be an active partner in the promotion of appropriate physical activity, and not only the target of a theoretical message to increase physical activity.[165] It is therefore suggested that as the pedometers provided were a novelty and the fact that an added responsibility of stepping had been given to the children, they had more incentive and motivation (as active partners) to complete the extra steps than the participants who were not instructed *per se* to complete the additional stepping.

In line with the 1996 Physical Activity and Health Report of the Surgeon General,[83] this study also found that female adolescents were less active than male adolescents (in terms of baseline daily activity), but the specific reasons for this difference remain unclear. A possible explanation for this in the context of this study specifically, is that the females did not seem to engage in as much physical activity during breaks at school, while the males typically engaged in soccer and cricket activities. This was not measured or quantified at any point but was the observation of the investigator during school visits.

A trend was also noted showing that the adolescents who were not overweight or obese, were in fact more active. Sometimes obese and overweight children avoid participation in certain activities for fear of being ridiculed or compared to their faster, more flexible normal weight peers (especially within the competitive school setting), and this could be the reason that the normal weight peers appeared to be slightly more active. Those adolescents classified as being 'overweight' however seemed to do more heavy intensity activity. It is possible that the study heightened awareness of an anticipated weight loss amongst the overweight group, causing them to engage in more high intensity activities than the other participants, and this can possibly be confirmed by the fact that the overweight participants had a slightly greater (although not significant) mean reduction in percentage body fat than the normal weight participants.

4.2 RTEC CONSUMPTION

Breakfast skipping has specifically been linked to purposes of dieting and has also been identified as a commonly enforced weight loss strategy.[23,83,93] According to Rampersaud and colleagues,[23] skipping breakfast is typically more prevalent in girls, and the YRBSS showed that among the female students investigated, 60% were attempting to lose weight at the time of the survey, whereas only 24% of the male students were participating in any weight loss strategies.[83] Although this study did not investigate weight loss strategies *per se*, the act of breakfast skipping was not found to be more prevalent amongst the girls. The demands for weight loss in this particular population, and the specific weight loss techniques employed could thus be an additional identifiable area for future investigations.

Rampersaud and colleagues reported that children and adolescents (not gender specific) skipped breakfast more than any other meal, and 42% of 12 to 13 year old children indicated that they did not eat breakfast every day.[23] In this study however, it is apparent that breakfast (regardless of nature) was consumed on most days by the group as a whole, within the specified study period. This may be because the whole investigated population was required to make diary recordings of their breakfast consumption, and this may have made them aware of consuming breakfast more frequently. Since there were no significant differences in the frequency of breakfast consumption between the cohorts to whom free breakfast cereal supplies were issued and those to whom none were issued, the availability of free cereal cannot be used as a possible explanation for the regular breakfast consumption.

When the consumption of RTEC for breakfast was viewed in isolation, the cohort to which the RTEC intervention alone had been prescribed showed a significantly higher consumption of RTEC servings for breakfast than the cohort to which no intervention had been prescribed. This can possibly be explained by the fact that the RTEC's were provided at no cost to the participants of the RTEC cohort, and in large enough quantities to last the duration of the 5-week study period, thus making it readily available for breakfast use with no financial impact on the family. The other cohort also receiving the RTEC also had a higher intake although not significant, which strengthens the previous argument. Alternatively, the lack of significant outcomes could (through extrapolation of reason) be explained by the US report that a quarter to a half of children aged 4 to 18 years regularly consume RTEC for breakfast.[86] Thus the fact that the RTEC and Step & RTEC cohorts were given 5-weeks free RTEC supplies simply increased the RTEC breakfast intake over and above an existing level of RTEC intake amongst all the participants, and particularly the non-RTEC intervention cohorts. The cost of these products nevertheless remains something to consider when health professionals make recommendations in a public health setup, and recommendations for the use of these RTEC products in the daily diet should be made in an informed manner, taking into account the habitual dietary patterns of the community being targeted, as well as the financial feasibility of advocating the daily use of such food items.

The act of snacking throughout the day has previously been reported to be slightly more in boys than in girls.[139] In our study, it was the act of afternoon snacking specifically that was investigated, and our findings showed that the males (although not significant) did not consume afternoon snacks (regardless of nature) on more days than did the female participants. This trend suggests that general afternoon snacking was greater in the females and this may be due to the fact that our particular study placed emphasis on afternoon snacking as an integral component of its interventions (noting that afternoon snacking was never specifically referred to as a means of inducing weight loss), which in turn may have been interpreted as a 'dieting' technique by the more 'body conscious' female adolescents.

Our study furthermore investigated the act of afternoon snacking on RTE breakfast cereals and RTEC snack bars, and our findings indicated that the males also did not consume more servings of RTE breakfast cereals as an afternoon snack. This higher intake of RTE breakfast cereals (and this includes RTEC other than the prescribed children's RTEC's as well) as an afternoon snack amongst the female adolescents may have been influenced by the study's overall emphasis on the use of RTEC products, and again its perceived association with weight loss. The males did however consume slightly more (although again not significantly more) servings of the RTEC snack bars as afternoon snacks.

When the findings were viewed in terms of cohort allocations, the frequency of afternoon snacking (regardless of nature) was significantly higher amongst the participants to whom the RTEC intervention had been prescribed. More specifically, they consumed significantly more RTEC snack bar servings as afternoon snacks. A Canadian report identified the top three reasons for snacking to be the facts that people liked the taste of snack foods, that they consumed snacks to satisfy their hunger and that snack foods are considered to be convenient.[143] The combination of the attractive and convenient packaging, gustatory appeal and novelty of the provided Kellogg's RTEC children's snack bars, as well as the fact that they were donated again with no financial implication to the family, may have been the reasons for the increased frequency of afternoon snacking, and specifically RTEC snacking, amongst the participants of these two cohorts.

Although the results of this study did not show a significant difference in the mean weight change achieved over the 5-week study period across the four cohorts, both (and only) the cohorts which exhibited a significantly greater mean intake of RTEC snack bars as afternoon snacks had a negative change in body weight.

Interestingly, the participants' change in body weight and change in percentage body fat were significantly positively correlated with the servings of RTEC consumed at times other than breakfast or as an afternoon snack. The mean servings of RTEC consumed as morning snack (0.04), lunch (0.20), dinner (0.15) and evening snack (0.04) across the whole study population however never reached full single servings (1), and so it is possible that these RTEC portions were not consumed as meals themselves, but instead as part of the actual meals under which they were reported. For example, the reported lunch and dinner servings of RTEC may have been consumed while waiting for the actual lunch or dinner meal to be prepared and served. This in turn would increase the participants' caloric intake for that meal, and consequently the participants' overall daily energy intake. This could then be the reason for the slight increases observed in both body weight and percentage body fat. Albertson and colleagues have in fact reported an association between body weight and RTEC consumption, such that higher intakes of RTEC for breakfast specifically were associated with lower BMI's, even though energy intake is usually higher in RTEC consumers versus non-consumers (probably due to the increased eating frequency which possibly promotes less efficient energy utilisation by increasing dietary induced thermogenesis [106]).[98] Furthermore, the literature states that reduced GI diets (such as the use if the intermediate composite breakfasts included in this study) may have a role in reducing overall daily caloric intake [126,132], while Ruxton and Kirk suggest that regular breakfast consumption may simply lower overall percentage calories from fat intake specifically.[105] However, as can be seen from our findings, the consumption of RTEC ad libitum needs to be carefully addressed when the use of RTEC products are advocated for use in the diet (be it for weight maintenance or weight loss) so as to avoid unnecessary increases in caloric intake under the erroneous belief that anytime RTEC use is an effective weight management strategy.

The lack of significant differences for all the variables of RTEC consumption between the obese, overweight and normal weight participants are also in line with the findings from studies of the estimates of daily energy intake in children living in industrialised countries.[31] These studies have not usually been able to show relative hyperphagia of obese subjects, while studies of energy balance conducted in free living conditions have revealed that obese children, as well as obese adolescents, usually have a higher daily TEE than non-obese subjects.[31] Maffeis concluded that this is a clear demonstration of the suspected underestimation of self-reported food intake, and the relative inaccuracy of the methods actually available to estimate food intake amongst obese individuals.[31]

4.3 WEIGHT CHANGES

At the start of the study period, there was no significant difference in the mean baseline body weight and mean percentage body fat across the four cohorts indicating that the cohorts were homogenous at baseline.

Laquatras reported that fat free mass (FFM) is higher in men than in women, supporting the findings in this study with female participants having higher mean initial and final percentage body fat than the males.[5] The male and female participants had mean initial percentages body fat of 19.39% and 25.58% respectively, which according to Gallagher and colleagues, as reported by Laquatra, fall within the ranges of total body fat (essential plus storage fat) associated with optimum health.[5] Fat in the body is categorised as either 'essential' (fat which is necessary for normal physiologic functioning and is stored in small amounts in the bone marrow, heart, lung, liver, spleen, kidneys, muscles, and lipid-rich tissues in the nervous system) or 'storage' (fat which serves as the primary reserve of the body, is stored as triglyceride in depots made up of adipose tissue, and accumulates under the skin and around the internal organs to protect them from trauma).[5] In males, about 3% of body fat is considered essential, and in women essential fat increases to about 12% as the sex-specific body fat in the breasts, pelvic regions and thighs develop.[5] Most storage fat in the body is considered expendable.[5]

Based on classifications of BMI (as per the age and gender specific classifications of Cole and colleagues [11]), there was a general shift over the course of the study from each classification level towards a lower and more acceptable BMI classification. A 2% increase in normal weight classifications, and a 1% decrease for both overweight and obese classifications was observed. The term 'obesity' has been defined as a condition of excess body fat, and although body fat expressed as a percentage of body weight (percentage body fat) is the most relevant measure against which anthropometric measurements should be correlated, the high reliability of weight and height measurements support the use of BMI (a variant of weight-for-height) as a more reliable measure of adiposity for use as a tool of comparison within and between populations.[28] Dietz and Bellizzi stated that on the basis of DEXA measurements, correlation coefficients between percentage body fat and BMI seem comparable among young boys and girls.[28] Although our study did not reveal major shifts in BMI classifications (again very likely impeded to some extent by the short study duration), the evident shifts were indeed positive, and illustrate the presence of some functional intervention strategy(ies).

In our study, it was the obese individuals (based on their final BMI classifications) who showed a significantly greater mean reduction in percentage body fat than the normal weight and overweight individuals. According to the National Institutes of Health (NIH) treatment recommendations, as reported by Laquatra, when the correct calorie deficits are implemented, persons with a BMI of 27 to 35 are expected to lose 0.5 to 1 lb per week (1.1 – 2.2kg), and those with a BMI greater than 35, the expected weight loss increases to 1 to 2 lb per week (2.2 – 4.4kg).[5] Furthermore, Lichtman and colleagues, as reported by Laquatra, stated that even with the same caloric intake, rates of weight reduction vary, such that the heavier the person, who because of their higher weight expends more energy than one who is less obese, loses faster than the lighter person.[5] Although our study did not implement calorie deficits *per se* (or at least changes in caloric intakes were not determined), the above recommendations and statements from the literature provide a possible explanation for our findings. It may thus be beneficial to allow for the determination of changes of in caloric intakes in similar future studies.

It should however be noted that according to the literature, TANITA systems have been found to render a mean error of 2.3 kg for fat mass in adolescent boys, with limits of agreement being 2.3 ± 7.8 kg.[181] It is possible then that even greater shifts in changes in body fat could have occurred in this study (even in light of the restricted time in which the compositional changes would have had to take place). Other more accurate methods of body composition analysis (including BODPOD software, body density, total body water and skinfold assessment methods),[181] were however not feasible options within the financial and logistical construct of this study, and TANITA foot-foot BIA systems are nevertheless considered to currently be acceptable methods of body composition in paediatrics.[181,182] It has been stated that although this method may be relatively poor in accuracy, it needs to be accepted until such time that future research produces appropriate reference data (required to aid in the correct interpretation of results), improving the accuracy of similar simple field and clinical methods of body composition estimation.[181,182]

There was no significant difference in the mean change in body weight and the mean change in BMI between the male and female participants, although the trends did indicate a greater mean decrease in both body weight and BMI by the male participants, while the male participants did in fact show a significantly greater mean decrease in percentage body fat. Lichtman and colleagues, as reported by Laquatra explains this by stating that males reduce weight faster than females of similar size because of their higher lean body mass (LBM) (the metabolically active tissue in the body [3]), and consequently higher resting metabolic rate (RMR).[5] The major single determinant of RMR is LBM, and females thus have metabolic rates that are approximately 5 to 10% lower than males of the same weight and height.[3] Measurement of LBM was logistically feasible in our study since the TANITA body composition monitor used to determine the participants' percentage body fat, is also able to perform muscle mass measurements, however, since the focus was on changes in adiposity, only the changes in weight and percentage body fat were accounted for. Particularly because of the inclusion of an intervention of physical activity, it is recommended that this measurement be included in future such studies as changes in muscle mass may provide further valuable insight into the relationships between the various interventions and body compositional changes.

The lack of any significant differences in mean change in BMI, mean change in weight or mean change in percentage body fat across the four cohorts at the end of the 5-week study period was possibly due to the short duration of the study. Laquatra states that a minimum of 2 months is needed to obtain any significant reductions in adipose tissue with any specific training program.[5] The result trends did however show an overall mean decrease in body weight, BMI and percentage body fat over the course of the 5 week study period. Both cohorts to whom RTEC consumption had been prescribed as an intervention had greater mean reductions in body weight and BMI than the remaining two cohorts (to whom either no intervention or increased physical activity alone was prescribed). These two latter cohorts in fact both showed a mean weight increase. In terms of changes in percentage body fat, all cohorts showed reductions but those to which an intervention had been prescribed showed greater mean reductions than the cohort to which no intervention had been prescribed.

Those increasing their steps only though actually exhibited the greatest increase in body weight and greatest decrease in body fat. Laquatra reported on studies of programs combining diet and exercise which have similarly shown that although there is no increase in weight loss in the exercising group over the diet alone, an increased loss of body fat does occur.[5] This may be explained by the fact that as physical exercise initially increases muscle mass, the LBM with its higher density replaces the fat (decreasing percentage body fat), maintaining or increasing the body weight, and that with continued exercise, the limited capacity of muscle mass to increase is overcome by the decrease in fat, resulting in a net decrease in body fat.[5]

In addition, a significant negative correlation was found between the change in percentage body fat and the total steps completed over the course of the 5-week study. According to Twisk,[45] body fatness and cardiopulmonary fitness are the only cardiovascular risk factors known to be influenced by physical activity, and while physical activity and dietary intake are highly linked to each other, a decrease in body fatness is only achieved when an increase in physical activity is accompanied by a decrease in energy intake.

Thus, although these findings show that increased regular exercise was the only variable to bring about a significant negative correlation with percentage body fat, it is not known whether or not the cohorts achieved a decrease in energy intake over the course of the study. It also appears that the common variable for a successful short term weight loss and decrease in BMI is that of regular RTEC consumption alone, and that increased physical activity alone results in the greatest decrease in body fat but not necessarily body weight or BMI. Laquatra stated that consistency is key to realizing the health and weight-management benefits of exercise,[5] and so further similar studies (of longer duration) need to be executed to determine whether the positive effects of single short-term interventions can be further strengthened by consistent increased physical activity, and combinations of RTEC and physical activity interventions.

Interestingly, there was no significant correlation found between the participants' change in percentage body fat and the minutes spent participating in the additional activities of very light, light and moderate intensities, while a significant positive correlation was found between the participants' change in percentage body fat and the minutes spent participating in additional activities of heavy intensity. In the available literature, Klesges and colleagues found an inverse relationship to exist between physical activity and BMI, and the strongest correlations were specifically between high BMI and low levels of physical activity and cardiovascular fitness.[56] Maffeis also reported that sedentary activities have been directly associated with adiposity levels.[31] On the other hand, there have been studies that have *not* been able to show these changes.[51,57] The physical laws of thermodynamics however emphasise that decreased physical activity does promote a positive energy balance,[31] and Young and colleagues have suggested that the discrepancies in these findings may in fact be due to the reality that the decrease in energy expenditure is simply too small to be measured by current methods for assessing physical activity levels.[22] Alternatively, the need for further experimental studies to validate the relationships between health outcomes such as adiposity and different frequencies, durations, modes and volumes of physical activities have also been emphasised.[45,80] The fact then that the methods implored for the recording of physical activity in this study were based on each participants' own subjective interpretation of his/her perceived duration, frequency, mode and volume of the performed activity, while the intensity of the activity was again broadly categorised according to a standardised table of physical activities of varying intensities, may be the possible reason for the lack of a clear explanation of this finding. However, since the overweight participants did in fact have a slightly greater (although not significant) mean reduction in percentage body fat than the normal weight participants, it is then indeed possible that there was some degree of over-reporting of heavy intensity activities amongst the normal weight participants, resulting in this unexpected positive correlation.

The correlations found between both the servings of RTEC breakfast consumed and the servings of RTEC snack bars consumed as afternoon snacks and the changes in percentage body fat in this study were indeed negative, but they were not found to be significant. A significant negative correlation was however found between the participants' change in weight over the 5-week study period and the servings of RTEC snacks (i.e. the low fat, sweet RTE Kellogg's children's cereal bars) consumed as an afternoon snack. In other words, as the number of RTEC snack servings consumed as afternoon snacks increased, so was a greater weight loss noted amongst the participants at the end of the 5-week study period. This finding is supported by the findings of the previously mentioned study by Lawton and colleagues, where habitual snacking and specifically the generous consumption of sweet and non-sweet low fat snacks (when compared to high fat snacks) was endorsed as an effective strategy to lower fat intake while taking care not to increase total energy intake.[142] The habitual low fat afternoon snacking in this study can thus be advocated as having a positive (in terms of desired weight loss) effect on the snackers' weight. Although it is not known (in quantitative terms) the kinds of afternoon snacks that the participants usually consumed, this may be an area that can be further explored in future studies so as to quantitatively allow for the assessment of usual afternoon snack caloric intakes between the various cohorts, and aid in explaining the above findings with more depth.

Lastly, the three interventions that were targeted in the execution of this study have all previously been identified as modifiable risk factors in the management and treatment of overweight and obesity, and an attempt was made to create more clarity on the effectiveness of each of these modifications, used alone and in combinations, in the prevention and management of overweight and obesity. In addition, the specific RTEC interventions advocated in this study allowed for the involvement of the parents in the home setting, and the physical activity interventions allowed for the involvement of the teachers in the school setting. Although the effectiveness of such a partially school- and partially home-based intervention was not directly measured in this study, this characteristic forms an integral component of the context in which this study was executed, and in turn may provide the basis for further investigations into its efficacy as an intervention strategy. It may also be beneficial to increase the degree of involvement of both the teachers and the parents in future studies amongst pre-adolescent populations. The parents could attend training sessions together with the children regarding the measurement of the RTEC breakfast cereal portions, the completion of the diaries, the use of pedometers and the recording of all the required variables of physical activity. On the other hand teachers could become more involved in ensuring the completion of the additional specified activity. Walking groups could perhaps be established and led by a specific teacher during break times for those participants to whom a stepping intervention was prescribed.

CHAPTER 5: CONCLUSIONS

The hypothesis of this study stated that a combination of regular increased physical activity, and regular consumption of RTEC breakfasts and afternoon snacks, would result in the greatest cumulative changes (decreases) in body weight, BMI classification and percentage body fat, amongst the young adolescents. The findings of this study indicate that the combination of interventions seems to have been less effective than both the single interventions in bringing about decreases in percentage body fat and body weight. The hypothesis of this study is thus rejected.

The stepping intervention brought about the greatest decrease in percentage body fat. Those increasing their steps only though also exhibited the greatest increase in body weight which is seen as the initial response of increased activity.

The greatest decrease in body weight and BMI was found in the group only increasing their RTEC consumption, followed by those consuming RTEC and stepping.

Both RTEC intervention cohorts showed significantly higher RTEC snack bar consumption as afternoon snacks specifically. Although only an observed trend, there was some evidence of decreasing percentage body fat with increasing servings of RTEC snack bars consumed as an afternoon snack and also with increasing servings of RTEC consumed for breakfast.

Although slight decreases were found in BMI, BMI classifications did not change greatly as it lacks sensitivity to small incremental changes and as a result of the short study duration.

In summary, it appears that any of the interventions (when compared to no intervention at all) were beneficial in bringing about some desired outcome, while regular RTEC breakfast consumption and snacking were beneficial in reducing weight, and increased physical activity was more beneficial in reducing body fat with a concurrent initial increase in body weight. Future inclusion of measurements of changes in muscle mass and caloric intakes will certainly be useful to further define these outcomes and provide more specific explanations for the observed changes.

Since decreasing adiposity or body fatness remains an integral component of any intervention strategy, it is necessary however that further similar studies (essentially of longer duration) be executed before determining whether increased regular physical activity alone or RTEC interventions alone will bring about the greatest benefits in the quest for the optimal and most feasible strategy in the prevention and management of overweight and obesity.

The role of the food and nutrition professional also became evident for advocating the correct use of and integration into the diet of RTEC products for optimal dietary and caloric benefits.

Lastly, this study was implemented as a primary intervention school-based health promotion program which targeted **all** pupils, as opposed to only targeting obese and overweight children. Although the obese participants showed a significantly greater decrease in percentage body fat than the normal or overweight participants, the implemented whole-school intervention approach allowed for a more holistic and less stigmatized intervention approach. The lifestyle behaviors which are modified at this point of the young adolescents' life should in fact benefit all young adolescents in either a preventative or intervention manner.

CHAPTER 6: LIMITATIONS AND RECOMMENDATIONS

There were a number of limitations to this study, the largest being that the study duration of 5-weeks was too short to detect significant changes in the measured anthropometric variables. Epstein and colleagues reviewed several clinical weight loss studies in 1998, and found that treatment periods of clinical behavioural studies lasted between two and 14 months and the period of follow-up ranged from eight months to 10 years. In most cases longer treatment resulted in greater weight loss among treatment groups than among control groups during treatment and at follow-up.[80] Initially this study had been planned for 6 weeks as this was all the time that the third school semester could allow for consecutive follow-up of the participants (ie. in an attempt to avoid running the study over a holiday period where routine and control would be further jeopardised, and also at the request of the respective headmasters to end the study prior to the commencement of the end-of-term examinations). Once the study commenced however, the duration was reduced to 5 weeks as one of the selected schools took their students away for a week of camping in the last scheduled week of the study. For purposes of homogeneity between the participants and interventions at the two schools, the overall study period had to be reduced to 5 weeks. It is recommended though that future studies be planned to run for the minimum period of two months, possibly allowing participants to start just before a short holiday period (where vacation trips are less likely to be planned), to continue the study through the holiday period and then ending just before the start of the exam period. This will allow for more pronounced changes in anthropometric variables to occur, and hence the attainment of more powerful outcomes.

In addition, Twisk emphasised the availability of many different ways to measure physical activity, varying from direct measurements (observation, diary, questionnaires, interview) to indirect measurements (physiological measurements, mechanical devices, 'doubly labelled' water).[45] Physiologic assessment techniques used in laboratory settings (measuring oxygen consumption and heart rate) are however inappropriate for measuring physical activity in large groups because of their intrusiveness and cost.[187] The use of the remaining optional methods in different studies can then lead to ambiguous results, and so regardless of what method is used, it is impossible to measure the exact amount of physical activity in children and adolescents.[45] Twisk stated that 'the best one can do is to get a crude indication of habitual physical activity'.[45] He also stated that the measurement error associated with the assessment of physical activity is generally not related to the health outcome, and those relationships (in the case of both under- and over-reporting) are often underestimated.[45] Thus, the lack of standardised approaches to measuring physical activity (its modes, intensities, and durations) and to then compare results to published literature, make it difficult to draw specific and valid conclusions from the data available. In this particular study, data from the physical activity questionnaire was converted to an activity measure of intensity using standard activity intensity tables (where the particular activity was related to a certain amount of energy expenditure) and the duration relied on the accuracy of the participants' duration report. According to Twisk, this method incorporates a new source of bias, since the intensity of the same activity is not only largely variable for different individuals, but also that different absolute levels of aerobic fitness between individuals can have important implications for the translation of certain activities into units or categories of energy expenditure.[45] Speck and colleagues however reported that a self-reported daily physical activity record (when compared concurrently with data from a validated pedometer and 7-day physical activity recall questionnaire), produced a statistically significant correlation between the three assessment methods, and hence suggested that self-reported daily physical activity records may in fact be considered useful in community health programs and community-based research.[188] An alternative option may have been to consider the use of a tool such as the Previous Day Physical Activity Recall (PDPAR) (a self-report instrument designed to measure physical activity in youth).[187] This tool is usually completed by the participant over the course of an hour, and could possibly have been completed by the participants on a weekly basis.

The use of inexpensive pedometers was essentially a limitation to the study in terms of revealing valid, reliable and objective step count data, and many of the participants also reported faulty mechanisms at the weekly follow-up meetings. These faulty mechanisms were replaced but often the participant had not then been able to record his/her daily steps completed for the days prior to the follow-up meeting. These invalid step counters did however still serve their purpose as a crude measurement of daily physical activity since the same invalid counters were used by the whole study population. The counters also well served their purpose as a rough counting guide for the participants required to perform increased daily activity and complete additional steps (specifically the participants in the Step and Step&RTEC cohorts). It is suggested that in future studies, validated pedometers be considered, as they will allow for more valid measurements of daily physical activity to be attained. Two pedometers which have been validated in paediatric and adolescent populations include the new Lifestyles Digiwalker SW-200 and the Computer Science and Application monitor (also known as MTI Actigraph).[185]

Furthermore, changes in muscle mass were not measured in this study because the common variable of change identified in studies on the effects of RTEC consumption and then physical activity on the weights of adolescents was that of body fat. Based on this, the focus of this study was specifically the changes in adiposity, and the consequent shifts in BMI classifications within the group as a whole based on the different interventions or lack thereof. It is however recommended that in future studies, muscle mass measurements be taken so that a more holistic view of the changes in body composition between the cohorts (and specifically amongst the cohorts performing increased physical activity) can be achieved, and so that the suspected explanations for changes in adiposity within the context of the current study can be validated and quantified. This measurement is logistically feasible, since the TANITA body composition monitor used to determine the participants' percentage body fat, is also able to perform lean body mass measurements.

The study population was also a very culturally and socio-economically diverse one, and an unofficial report was made to the investigator that some of the less affluent participants had sold some of their RTEC supplies in exchange for cash. The long-term feasibility of the RTEC consumption intervention and the applicability of RTEC as an ideal breakfast option is then also questionable in a family where the socio-economic status is poor. Data on family income and urbanisation was clearly beyond the scope of this study, but their proven association with weight and adiposity could indeed have had some relative effect on the participants' weight and adiposity changes. It might be useful to consider performing a similar study in a more affluent environment, accounting for the potential confounding effects of sharing the sponsored 'luxury' supplies within the household, and the appeal of gaining cash from freely supplied food items.

Lastly, in order to achieve a confidence interval of 95 %, and an error % or precision (Cp) of 14 % from the large Grade five, six and seven pupil population of public schools in the Ekhuruleni East and West districts of Gauteng, the sample size of each cohort needed to be at least 49 participants. There was however a response rate of only 60.57% , and a 56.1% compliancy, resulting in a sample size of 31, 29, 34 and 25 participants in the Control, Step, RTEC and Step & RTEC cohorts respectively. This in turn resulted in a limited power of the study as a whole. It is recommended that in future studies, assuming a similar response rate of approximately 56 %, the investigator should aim to have approximately 88 participants in each cohort to ensure attainment of the desired confidence interval and precision of the study.

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ADDENDA

Addendum 1: Reference list of standardised RTEC servings used for data capturing (standardised RTEC servings were only determined for those RTEC actually reported in the returned recording diaries)

Ready-To-Eat-Cereal (RTEC)	Single serving
Weetbix	2 biscuits
Rice Crispies	350 ml
Strawberry pops	250 ml
Coco pop Crunchers	250 ml
Frosties	250 ml
All Bran Flakes	300 ml
All Bran honey nut	150 ml
Cornflakes	300 ml
Special K	150 ml
High fibre bran	250 ml
Pronutro	125 ml dry

Addendum 2: Information letter sent out to all parents/guardians during recruitment

Loving Lifestyle

Dear Parents and Pupils of Tom Newby Primary School,

Welcome to the 'Loving Lifestyle' study.

Your school has been selected as one of only two schools in Gauteng to participate in this study. A dietician registered with the Health Professionals Council of South Africa (HPCSA) will perform the study, and the results will form part of a Masters dissertation. The study has also been approved by the Gauteng Department of Education (GDE).

Should you agree to participate in the study, I would need both parent and pupil to sign the attached consent form, and the pupil to complete the attached questionnaire. The first 100 pupils to return their completed consent forms and questionnaires to the school, will be allocated a place in the program.
Once you have been allocated a place in the program, you will also stand the chance of winning one of four 'Crosstrainer' vouchers to the value of R400-00 each.

The support of both parents and pupils of Tom Newby Primary School, will play an essential role in the success of this study, and in the development of effective programs for the prevention and management of overweight and obesity amongst the young adolescent populations of South Africa.

Attached is a description of the 6-week 'Loving Lifestyle' program, and if there is anything more that you would like to know about the study, please feel free to contact Andri on 083 260 5087.

Yours truly,

Andri Philippou
(Registered Dietician)

Mr Manolios
(Headmaster Tom Newby Primary School)

healthy and strong all day long!

Androulla Philippou ... Dietician
Mobile: 083 260 5087

Addendum 3: General informed consent and assent form (English only) for all prospective participants

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM FOR USE BY LEGAL GUARDIANS.

TITLE OF THE RESEARCH PROJECT:
To determine the effect of regular increased physical activity, and regular consumption of Ready-To-Eat-Cereal (RTEC) breakfasts and snacks, on the weight of young adolescents attending public Gauteng schools.

REFERENCE NUMBER: Pending

PRINCIPAL INVESTIGATOR: Androulla Philippou

ADDRESS: 13 Bekker Road Dalview
Brakpan, 1541
Gauteng, South Africa

CONTACT NUMBER: 083 260 5087

Your child is being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask the study staff any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how your child could be involved. Also, your child's participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw him/her from the study at any point, even if you do initially agree to take part.

This study has been approved by the Committee for Human Research at Stellenbosch University and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.

What is this research study all about?
The aim of this study is to compare the changes in weight and body fat between four groups of children, each of whom will be given a different set of instructions (regarding physical activity, breakfast consumption and snacking) to follow for 6 weeks.
This project aims to address (in part) the global obesity epidemic, by examining the effect of these lifestyle factors (physical activity and diet) on young adolescents. This project could then provide the basis for the development and implementation of intervention programs, which focus on the modification of these risk factors, for the prevention and management of overweight/obesity amongst young adolescents.

Each selected pupil will be allocated to one of four groups, based on random allocation, while simultaneously taking into account the pupils' responses to the initial participation questionnaire, which will act as an indication of his/her willingness to eat specified RTEC servings at specified times for the duration of the six week study period, and as an indication of his/her willingness to do a prescribed physical stepping activity at prescribed times for the duration of the six week study period. All the participants (regardless of group allocation), will be required to record what they consumed for breakfast (if anything), what they consumed as an afternoon snack between lunch and dinner (if anything), to record each portion of Ready-To-Eat cereal or Ready-To-Eat-Cereal snack consumed (if any), to record the number of daily steps during each school day, and to record whether or not they participated in any form of other physical activity, together with the type of other physical activity and the time spent doing the activity. This will need to be recorded on each weekday, for the duration of the six week study period.

To measure the daily number of steps taken during each school day, each participant will be given a pedometer, which is a small device that is worn around the midline of the waist, for the duration of the school day. To measure the RTE cereal portions consumed (if any), each participant will be given a set of measuring cups. The wrappers/containers of any RTEC snacks consumed, will need to be collected and stored in a brown 'Loving Lifestyle' envelope that will be provided to each participant.

Each of the four groups will however also have a unique and specific set of instructions which the participants allocated to that specific group, will need to follow for the six week study period.
The participants will also be assessed on two separate occasions (once on the first day of the six week study period, and again on the last day of the six week study period).
The following procedures will be performed on the two assessments occasions:

a) Measuring weight
b) Measuring height
c) Measuring percentage body fat using a Tanita Innerscan body composition monitor

None of the above-mentioned procedures are considered to be invasive. They will not be painful in any way, and will all be carried out according to standard procedures.

Why has your child been invited to participate?
Your child's school has been selected from the public schools in the Ekurhuleni East and West districts of Gauteng, complying with the following criteria:

- English teaching medium
- Co-ed institution
- Approval for participation granted by schools headmaster.

Your child falls within the target group of young adolescents between the ages of 10 and 13 years old, being investigated.

What will your child's responsibilities be?
Depending on the group to which your child will be allocated, his/her responsibilities will be as follows:

- Control group

a) To wear a pedometer and document total steps taken on each week day of the six-week study period
b) To document participation in any form of physical activity on each weekday of the six-week study period (Type of physical activity and duration of participation to be recorded)
c) To record all items of food consumed for breakfast on each weekday of the six-week study period.

d) To record all items of food consumed for afternoon snack on each weekday of the six-week study period.
e) To record any additional consumption (ie. at any time other than at breakfast and/or as an afternoon snack during the day) of RTEC product(s) on each weekday of the six-week study period.

Your child will also have to attend a 30-minute assessment on the first day of the six week study period, and a second 30-minute assessment on the last day of the six week study period. Both these assessments will take place during the school day, at times approved by both the headmaster and the relevant teachers of your child's school.

- Step group
  a) To wear a pedometer and document total steps taken on each week day of the six-week study period
  b) To complete and record completion of an additional 2 000 steps in a 20-minute period of time, on three separate occasions, during each school week of the six week study period
  c) To document participation in any form of physical activity on each weekday of the six-week study period (Type of physical activity and duration of participation to be recorded)
  d) To record all items of food consumed for breakfast on each weekday of the six-week study period.
  e) To record all items of food consumed for afternoon snack on each weekday of the six-week study period.
  f) To record any additional consumption (ie. at any time other than at breakfast and/or as an afternoon snack during the day) of RTEC product(s) on each weekday of the six-week study period.

Your child will also have to attend a 30-minute assessment on the first day of the six week study period, and a second 30-minute assessment on the last day of the six week study period. Both these assessments will take place during the school day, at times approved by both the headmaster and the relevant teachers of your child's school.

- RTEC group
  a) To wear a pedometer and document total steps taken on each week day of the six-week study period
  b) To document participation in any form of physical activity on each weekday of the six-week study period (Type of physical activity and duration of participation to be recorded)
  c) To record all items of food consumed for breakfast on each weekday of the six-week study period. Included in the items consumed for breakfast, the intervention will require that the participants consume a specified portion of RTEC with low fat milk on each of the weekdays of the six-week study period.
  d) To record all items of food consumed for afternoon snack on each weekday of the six-week study period. Included in the items consumed for afternoon snack, the intervention will require that the participants consume a specified RTEC snack bar.
  e) To record any additional consumption (ie. at any time other than at breakfast and/or as an afternoon snack during the day) of RTEC product(s) on each weekday of the six-week study period.

Your child will also have to attend a 30-minute assessment on the first day of the six week study period, and a second 30-minute assessment on the last day of the six week study period. Both these assessments will take place during the school day, at times approved by both the headmaster and the relevant teachers of your child's school.

- Step & RTEC group
  a) To wear a pedometer and document total steps taken on each week day of the six-week study period
  b) To complete and record completion of an additional 2 000 steps in a 20 minute period of time, on three separate occasions, during each school week of the six week study period
  c) To document participation in any form of physical activity on each weekday of the six-week study period (Type of physical activity and duration of participation to be recorded)
  d) To record all items of food consumed for breakfast on each weekday of the six-week study period. Included in the items consumed for breakfast, the intervention will require that the participants consume a specified portion of RTEC with low fat milk on each of the weekdays of the six-week study period.
  e) To record all items of food consumed for afternoon snack on each weekday of the six-week study period. Included in the items consumed for afternoon snack, the intervention will require that the participants consume a specified RTEC snack bar.
  f) To record any additional consumption (ie. at any time other than at breakfast and/or as an afternoon snack during the day) of RTEC product(s) on each weekday of the six-week study period.

Your child will also have to attend a 30-minute assessment on the first day of the six week study period, and a second 30-minute assessment on the last day of the six week study period. Both these assessments will take place during the school day, at times approved by both the headmaster and the relevant teachers of your child's school.

Will your child benefit from taking part in this research?

The outcomes of this study will benefit overweight and obese adolescents directly by helping to identify lifestyle modifications that will improve and/or control overweight and obesity. This in turn will assist the quest of health professionals to design successful intervention programs for the prevention and treatment of overweight and obesity amongst young adolescents.

The outcomes will also benefit the participating children (specifically the children in the 3 groups who have to change some aspect of their physical activity behaviour and/or of their diet) by practically introducing positive lifestyle behaviours into their daily routines.

All participating children however, will benefit from the study in terms of acquired knowledge of positive lifestyle behaviours, which they will gain from the direct study feedback that will be presented at the end of the study.

Are there any risks associated with your child taking part in this research?

There are no risks associated with your child taking part in this research.

If you do not agree to allow your child to take part, what alternatives does your child have?

Your child will simply not need to participate in the designated class and home activities.

Who will have access to your child's medical records?
The information collected will be treated as confidential and protected. The records of each child will be labelled with an allocated participant identification number. Only the principle investigator (Androulla Philippou), the study leader (Mrs Debbi Marais) and the study co-leader (Mrs Janicke Visser), will have access to your child's assessment records.
If the information collected is used in a publication or thesis, the identity of the participant will remain anonymous.

What will happen in the unlikely event of your child getting injured in any way, as a direct result of taking part in this research study?
There is no risk of injury in any way that can be seen as a direct result of taking part in this research study.

Will you or your child be paid to take part in this study and are there any costs involved?
Neither you nor your child will be paid to take part in the study. The investigator will provide all participants with the required recording materials, RTE cereals (where applicable), RTEC snacks (where applicable), milk (where applicable), measuring cups and pedometers.

Is there anything else that you should know or do?

- You can contact Androulla Philippou at 083 260 5087 if you have any further queries or encounter any problems.
- You can contact the Committee for Human Research at 021-938 9207 if you have any concerns or complaints that have not been adequately addressed by your study investigator.
- You will receive a copy of this information and consent form for your own records.

Assent of Minor
I (Name of Child/Minor)………………………………………………., have been invited to take part in the above research study.

- The study investigator and my parents have explained the details of the study to me and I understand what they have said to me.
- They have also explained that this study will involve measuring my weight and height, and measuring percentage body fat.
- I also know that I am free to pull out of the study at any time if I am unhappy.
- By writing my name below, I agree to take part and I agree that I have not been forced either by my parents or the investigator to take part.

………………………….. ………………………..
Name of Child (to be written by child if possible) Independent Witness

By signing below, I (*name of parent/legal guardian*)…………………………….. agree to allow my child *(Name of Child)*………………………………………………. who is ……………..years old, to take part in a research study entitled: **To determine the effect of regular increased physical activity, and regular consumption of Ready-To-Eat-Cereal (RTEC) breakfasts and snacks, on the weight of young adolescents attending public Gauteng schools.**

I declare that:

- I have read or had read to me this information and consent form and it is written in a language with which I am fluent and comfortable.
- If my child is older than 7 years, he/she must agree to take part in the study and his/her ASSENT must be recorded on this form.
- I/We have had a chance to ask questions and all our questions have been adequately answered.
- I/We understand that taking part in this study is **voluntary** and we have not been pressurized to take part.
- I/We may choose to leave the study at any time and will not be penalized or prejudiced in any way.
- My child may be asked to leave the study before it has finished, if the study investigator feels it is in my child's best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*)…………………………..on (*date*) ……………………………2006

…………………………………….…….. ……………………………………

Signature of Parent/Legal Guardian Signature of Witness

Declaration By Investigator

I (name) ……………………………………………….declare that:

- I explained the information in this document to ……………………………..
- I encouraged him/her/them to ask questions and took adequate time to answer them.
- I am satisfied that he/she/they adequately understand all aspects of the research, as discussed above
- I did/did not use a translator (*If a translator is used then the translator must sign the declaration below).*

Signed at (*place*)…………………………..on (*date*) ………………………………2006

…………………………………..….. ……………………………………

Signature of Investigator Signature of Witness

Declaration By Translator

I (*name*) ……………………………………………….declare that:

- I assisted the investigator (*name*)…………………………. to explain the information in this document to (*name of parent/legal guardian*) ……..……………………………….……., using the language medium of Afrikaans/Xhosa.
- We encouraged him/her/them to ask questions and took adequate time to answer them.
- I conveyed a factually correct version of what was related to me.
- I am satisfied that the legal guardian fully understands the content of this informed consent document and has had all his/her questions satisfactorily answered.

Signed at (*place*)…………………………..on (*date*) ……………………………2006

…………………………………... …………………………………..

Signature of Translator Signature of Witness

Addendum 4: Participant questionnaire for prospective participants (used during recruitment)

Once you and your parent(s) have completed the consent form, please complete the following the questionnaire, and then return both ***completed*** *documents to your teacher.*

Name: ____

Sex: Male ________________Female ___________________

Contact num: ______________________________

Class: ______________________________

Teacher: ________________________________

QUESTION 1	
Do you have any known food allergies?	
Yes	**No**
QUESTION 2	
Do you follow a specific/special/therapeutic diet on a daily basis?	
Yes	**No**
QUESTION 3	
Will you be fasting (for any religious or other reason(s)) for more than one day at a time, during the 3rd school term?	
Yes	**No**

QUESTION 4			
During a normal school week, do you eat breakfast before you start your school day?			
Every day	**Most days:** I don't eat breakfast every day, but I eat breakfast on 3 or more days of the school week	**Sometimes:** I eat breakfast less than 3 times during the school week	**Never:** I never eat breakfast during the school week

QUESTION 5
If you **do** eat breakfast during the school week, what kind of food do you have for breakfast?

QUESTION 6	
If you were placed in the group that has to eat the specified portion of Kellogg's breakfast cereal for breakfast on each school day of the 6-week program, would you be willing to do so?	
Yes	**No**

QUESTION 7	
Do you plan on doing any sport or exercise (more than once a week), during the third term?	
Yes	**No**

QUESTION 8
If you answered YES, please explain what **type** of sport or exercise you plan to do during the third term.

QUESTION 9	
If you were placed in the group that has to complete 2 000 steps in 20 minutes, on 3 separate days of each school week, during the 6 week program, would you be willing to do so?	
Yes	**No**

Addendum 5: Sample class list for participant cohort allocations

X PRIMARY SCHOOL RESEARCH PARTICIPANTS

GRADE 6 A – MRS X

Num	Student name	Sex	Contact number	Will eat cereal	Will do steps	Final consent for participation	Random group allocation	Starting date
1							Control	Monday 28.08.06
2							Step	Monday 28.08.06
3							RTEC	Monday 28.08.06
4							Step & RTEC	Monday 28.08.06
5							Control	Monday 28.08.06
6							Step	Monday 28.08.06
7							RTEC	Monday 28.08.06
8							Step & RTEC	Monday 28.08.06
9							Control	Monday 28.08.06
10							Step	Monday 28.08.06
11							RTEC	Monday 28.08.06
12							Step & RTEC	Monday 28.08.06
13							Control	Monday 28.08.06
14							Step	Monday 28.08.06
15							RTEC	Monday 28.08.06

Addendum 6: List of RTEC breakfast and snack products available on the market

Kellogg's RTE cereals	
Coco pops (crunch, caramel)	Hunny B's
Froot Loops	Rice Krispies
Frosties	Special K (Red Berry, Original)
Strawberry pops	Nutrific
Hi-fibre bran	All Bran flakes, All Bran fruitful
Honey nut crunch	Cornflakes
Kelloggs RTEC snacks	
All bran bars (original, cranberry)	Rice Krispies Treats
Cornflake cereal and milk bars	Special K (Red Berry, Peach and Apricot)
Coco pop cereal and milk bars	
Bokomo RTE cereals	
Rice crunchies Strawberry	Cornflakes
Choco scoops	Oatees
Fibre plus	Rainbow crunchies
Cerix (puffed wheat, strawberry, sugar frosted)	Weetbix, Weetbix salt/sugar free, Nu Bix, Oat Bix, Bran Bix
Pronutro (regular, banana, chocolate strawberry, wholewheat original, wholewheat apple bake, wholewheat honey melt)	Pronutro flakes
Instant oats (caramel, peach and apricot, strawberry, traditional)	Flakes (wheat, bran, honey, fruity)
Muesli (swiss, morning harvest, raisin, luxury berry, luxury citrus)	
Bokomo RTEC snacks	
Ready To Drink Up and Go (Banana, Strawberry, Chocolate, Vanilla)	Breakfast bars (citrus, apple and pineapple, rainsins)
Tiger Foods RTE cereals	
Jungle Muesli (Strawberry yoghurt, lifestyle, tropical fruit, nuts and raisins, raisins)	Oatso easy (apple cinnamon, banana and toffee, caramel, chocolate, natural, strawberry yoghurt, tropical fruit)
Tiger Foods RTEC snacks	
Jungle Energy Munch Crunchie (yoghurt, choc chip, apricot and almond)	

Natures Source RTE cereals	
Muesli (original, tropical cluster, toasted nut crunch, nutzy crunch, muesli crunch, crispy crunch, luxury swiss)	Apple and Cinnamon cereal
Lite and Crispy cereal	Mixed berries cereal
Orange spices cereal	Strawberry yoghurt clusters
Choc bitz	
Spar RTE cereals	
Muesli (wholenut crunch, breakfast crunch)	Bran flakes
Corn flakes	
Others	
Alpen muesli (original swiss, tropical, lite)	

Addendum 7: Welcome letter confirming participants cohort allocation

Loving Lifestyle

Dear participant,

Congratulations and **welcome** to the **'Loving Lifestyle'** program!

You have been allocated to the group!

This means that you will be required to complete the following tasks for the next six weeks:

The breakdown of the tasks specific to the cohort to which the participant has been allocated will be included here. This will be in the same format as which it appears in the cohort specific consent form that each participant will receive after having being allocated to a cohort.

I sincerely hope that you will enjoy every minute of this six week program, and if you have any questions, concerns or problem, please feel free to contact me at any time on 083 260 5087.

Yours truly,

APhilippou

Androulla Philippou

healthy and strong all day long!

Androulla Philippou RD (SA) BDietics (Pretoria) Dietician
Office: 011 488 4348 - Fax: 011 740 2319 - Mobile: 083 260 5087 - email: androulla@webmail.co.za

Addendum 8: 'Loving Lifestyle' food/activity diary cover page

Addendum 9: Sample of diary page(s) used for recording breakfast, afternoon snack, RTEC consumption and daily steps taken during school day (participants allocated to Control and RTEC cohorts)

Today is 28 August 2006, Monday

SECTION 1: BREAKFAST (meal eaten before school starts)			
a) Did you eat breakfast today?		YES	NO
b) If you ***did*** eat breakfast today:			
WHAT did you eat?	**HOW MUCH** did you eat?	If it was a **RTEC** that you ate, measure it as follows:	For official use only (***DO NOT*** *fill in*)
		___ * __________ ml cup ___ * __________ ml cup ______________ * bar (s)	RTEC Servings: _______ RTEC Snack Servings: __
		___ * __________ ml cup ___ * __________ ml cup ______________ * bar (s)	RTEC Servings: _______ RTEC Snack Servings: __
		TOTALS	RTEC Servings: ______ RTEC Snack Servings:__________

SECTION 2: AFTERNOON SNACK (anything eaten between lunch and dinner)			
a) Did you eat an afternoon snack today?		YES	NO
b) If you ***did*** eat an afternoon snack today:			
WHAT did you eat?	**HOW MUCH** did you eat?	If it was a **RTEC** that you ate, measure it as follows:	For official use only (***DO NOT*** *fill in*)
Time: ______________		___ * ____________ ml cup ___ * ____________ ml cup ________________ * bar (s)	RTEC Servings: _______ RTEC Snack Servings:___
Time: ______________		___ * ____________ ml cup ___ * ____________ ml cup ________________ * bar (s)	RTEC Servings: _______ RTEC Snack Servings:___
Time: ______________			
Time: ______________			
		TOTALS	RTEC Servings: ______ RTEC Snack Servings: __________

SECTION 3: READY-TO-EAT CEREALS (RTEC) and RTEC SNACKS				
If you ate a Ready-to-Eat Cereal (RTEC) product (cereal or snack), at **any other time** during the day (that means at any time **other than** at **breakfast** or as an **afternoon snack**), please fill in the following section:				
What **TIME** did you eat the RTEC?	What **MEAL** would you say the RTEC formed part of? • Lunch/ Dinner • Morning / Evening snack	Give a FULL name of the product eg. • **Manufacturer** (who makes the product) • **Product name** (what is the product called) • **Product description** (what flavour is the product)	**HOW MUCH** of the RTEC did you eat?	For official use only *(**DO NOT** fill in)*
		• • •	___ * ________ ml cup ___ * ________ ml cup ____________ * bar (s)	**RTEC Servings:** ___ **RTEC Snack Servings:** ___
		• • •	___ * ________ ml cup ___ * ________ ml cup ____________ * bar (s)	**RTEC Servings:** ___ **RTEC Snack Servings:** ___
		• • •	___ * ________ ml cup ___ * ________ ml cup ____________ * bar (s)	**RTEC Servings:** ___ **RTEC Snack Servings:** ___
For official use only *(**DO NOT** fill in)*	L: ________ RTEC ________ RTECS D: ________ RTEC ________ RTECS MS: ________ RTEC ________ RTECS ES: ________ RTEC ________ RTECS		**TOTALS**	**RTEC Servings:** ___ **RTEC Snack Servings:** ___

SECTION 4: COUNTING YOUR STEPS
Now that it is HOME TIME, check your pedometer and write down how many steps IN TOTAL you have taken at school today: **Number of steps:** ____

SECTION 5: EXERCISE
Did you do any exercise today? **YES** ____________________ **NO** ____________________
If you answered YES, then remember to go to your 'weekly exercise page' and fill in the details about your exercise

Addendum 10: Sample of diary page(s) used for recording breakfast, afternoon snack, RTEC consumption, daily steps taken during school day and number of additional steps taken in prescribed stepping sessions (participants allocated to Step and Step & RTEC cohorts)

Today is 28 August 2006, Monday

SECTION 1: BREAKFAST (meal eaten before school starts)			
a) Did you eat breakfast today?		YES	NO
b) If you ***did*** eat breakfast today:			
WHAT did you eat?	**HOW MUCH** did you eat?	If it was a **RTEC** that you ate, measure it as follows:	For official use only *(**DO NOT** fill in)*
		___ * __________ ml cup ___ * __________ ml cup ______________ * bar (s)	RTEC Servings: _______ RTEC Snack Servings: __
		___ * __________ ml cup ___ * __________ ml cup ______________ * bar (s)	RTEC Servings: _______ RTEC Snack Servings: __
		TOTALS	RTEC Servings: ______ RTEC Snack Servings:__________

SECTION 2: AFTERNOON SNACK (anything eaten between lunch and dinner)			
a) Did you eat an afternoon snack today?		YES	NO
b) If you ***did*** eat an afternoon snack today:			
WHAT did you eat?	**HOW MUCH** did you eat?	If it was a **RTEC** that you ate, measure it as follows:	For official use only *(**DO NOT** fill in)*
Time: ______________		___ * ____________ ml cup ___ * ____________ ml cup ________________ * bar (s)	RTEC Servings: _______ RTEC Snack Servings:___
Time: ______________		___ * ____________ ml cup ___ * ____________ ml cup ________________ * bar (s)	RTEC Servings: _______ RTEC Snack Servings:___
Time: ______________			
Time: ______________			
		TOTALS	RTEC Servings: ______ RTEC Snack Servings: ___________

SECTION 3: READY-TO-EAT CEREALS (RTEC) and RTEC SNACKS				
If you ate a Ready-to-Eat Cereal (RTEC) product (cereal or snack), at **any other time** during the day (that means at any time **other than** at **breakfast** or as an **afternoon snack**), please fill in the following section:				
What **TIME** did you eat the RTEC?	What **MEAL** would you say the RTEC formed part of? • Lunch/ Dinner • Morning / Evening snack	Give a FULL name of the product eg. • **Manufacturer** (who makes the product) • **Product name** (what is the product called) • **Product description** (what flavour is the product)	**HOW MUCH** of the RTEC did you eat?	For official use only *(**DO NOT** fill in)*
		• • •	___ * ________ ml cup ___ * ________ ml cup ____________ * bar (s)	**RTEC Servings:** __ **RTEC Snack Servings:** __
		• • •	___ * ________ ml cup ___ * ________ ml cup ____________ * bar (s)	**RTEC Servings:** __ **RTEC Snack Servings:** __
		• • •	___ * ________ ml cup ___ * ________ ml cup ____________ * bar (s)	**RTEC Servings:** __ **RTEC Snack Servings:** __
For official use only *(**DO NOT** fill in)*	L: ________ RTEC ________ RTECS D: ________ RTEC ________ RTECS MS: ________ RTEC ________ RTECS ES: ________ RTEC ________ RTECS		**TOTALS**	**RTEC Servings:** __ **RTEC Snack Servings:** __

SECTION 4: COUNTING YOUR STEPS
Now that it is HOME TIME, check your pedometer and write down how many steps IN TOTAL you have taken at school today: **Number of steps:** ____

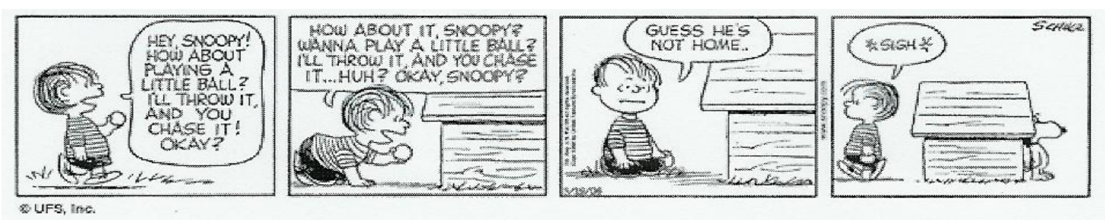
SECTION 5 : COUNTING YOUR EXTRA STEPS		
a) Are you doing your extra 'steps' today?	YES	NO
b) Are you doing your extra 'steps' **DURING** school or **AFTER** school today?	DURING SCHOOL	AFTER SCHOOL
	If you 'step' **DURING** school: Write down the number of steps on your pedometer **BEFORE** you start: ______________ Write down the number of steps on your pedometer **AFTER** you finish: ______________	If you 'step' **AFTER** school: Press **RESET** on your pedometer before you start: Write down the number of steps you took in the 20-minute 'stepping' session _____________
How **LONG** did you 'step' for today?	Time (minutes):	Time (minutes):
For official use only *(**DO NOT** fill in)*	**Total extra steps today** (After - Before): _____________________________	**Total extra steps today** (As above): ________________________
	Total steps at school ***(Total steps at school – Total extra steps):***_______________	Total steps at school *(As reported in section 4):* ______________________
	Time (minutes):	*Time (minutes):*

SECTION 6: EXERCISE
Did you do any exercise today? **YES** ______________________ **NO** ______________________
If you answered YES, then remember to go to your 'weekly exercise page' and fill in the details about your exercise

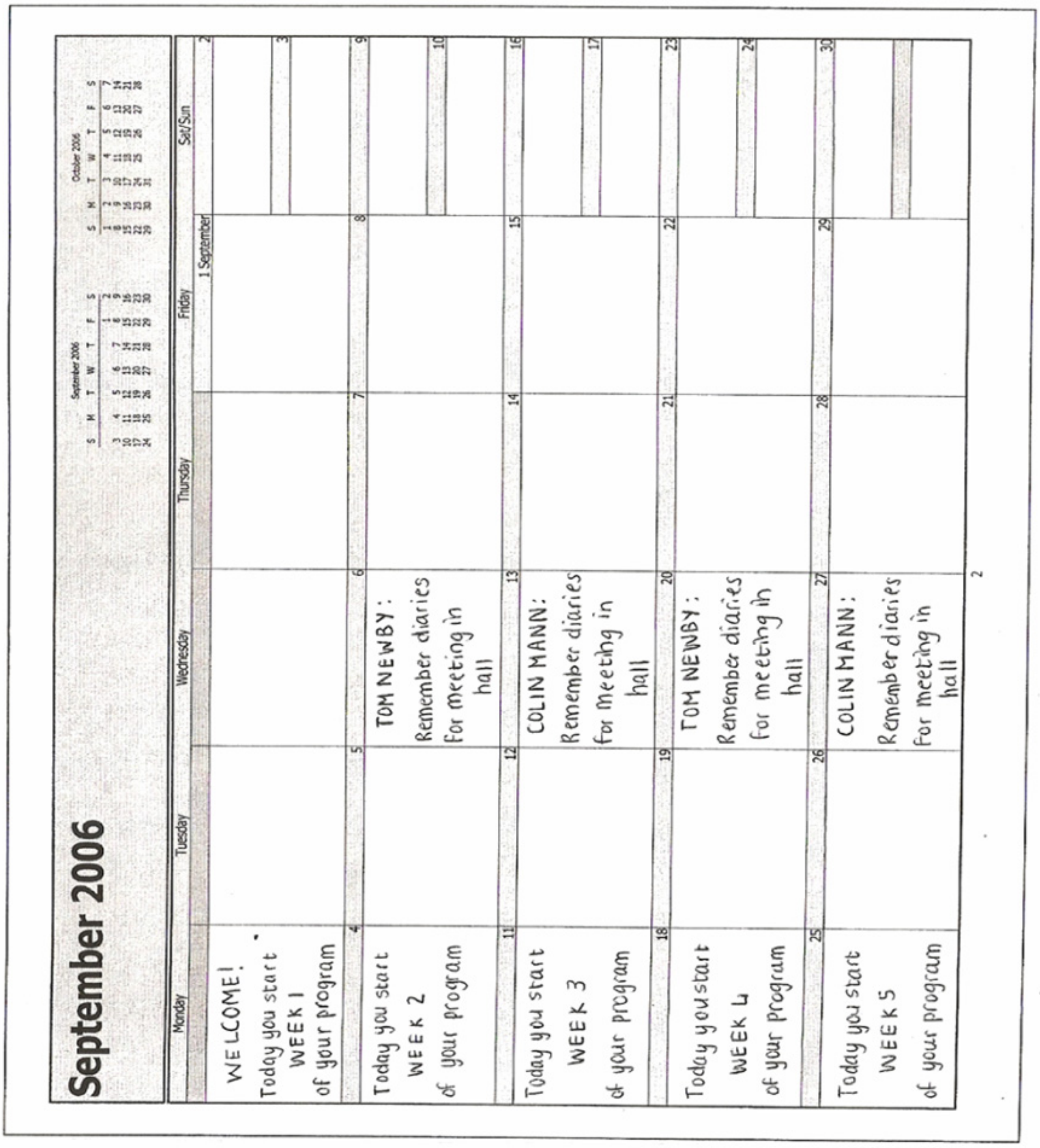
Addendum 11: Sample of diary page to be used for recording of any physical activity in which participants may have participated in, on weekdays during the five week study period (for participants in all cohorts)

WEEKLY EXERCISE PAGE – WEEK 1

DATE	WHAT TYPE OF EXERCISE DID YOU DO?	HOW LONG DID YOU EXERCISE FOR (minutes)?	For official use only
Monday 28 August 2006			**Very light** __________ **Light** ______________ **Moderate** __________ **Heavy** _____________
Tuesday 29 August 2006			**Very light** __________ **Light** ______________ **Moderate** __________ **Heavy** _____________
Wednesday 30 August 2006			**Very light** __________ **Light** ______________ **Moderate** __________ **Heavy** _____________
Thursday 31 August 2006			**Very light** __________ **Light** ______________ **Moderate** __________ **Heavy** _____________
Friday 1 September 2006			**Very light** __________ **Light** ______________ **Moderate** __________ **Heavy** _____________
TOTAL			**Very light** __________ **Light** ______________ **Moderate** __________ **Heavy** _____________



Addendum 12: Sample of calendar of events (assessments dates, weekly meeting dates, starting and ending dates) included in 'Loving Lifestyle' diary



September 2006

Monday	Tuesday	Wednesday	Thursday	Friday	Sat/Sun
				1 September	2 / 3
WELCOME! Today you start WEEK 1 of your program					
4	5	6	7	8	9 / 10
Today you start WEEK 2 of your program		TOM NEWBY: Remember diaries For meeting in hall			
11	12	13	14	15	16 / 17
Today you start WEEK 3 of your program		COLIN MANN: Remember diaries for meeting in hall			
18	19	20	21	22	23 / 24
Today you start WEEK 4 of your program		TOM NEWBY: Remember diaries for meeting in hall			
25	26	27	28	29	30
Today you start WEEK 5 of your program		COLIN MANN: Remember diaries For meeting in hall			

2

Addendum 13: Standardised data capturing form available for each participant

- A blank cover page with the participant identification number will precede this document so as to ensure participant confidentiality

SECTION 1: Socio-demographic data

	Date of initial assessment	______ 28 August 2006 ______ 29 August 2006 ______ 30 August 2006 ______ 31 August 2006
A	**Participant identification number**	____________________________
B	**Date of birth**	____________________________
C	**Age**	__________ years __________ months
D	**Gender**	__________ Male __________ Female
E	**Race**	_________ Black _________ White _________ Indian _________ Asian _________ Coloured

SECTION 2: Anthropometric assessment data

	INITIAL ASSESSMENT Date:	**FINAL ASSESSMENT** **Date:**
F **Weight (Kg)**		
G **Height (m)**	a) b) Average: ________________	a) b) Average: ________________
H **BMI (kg/m^2)**		
I **WHO classification**		
J **BMI for age (percentile)**		
K **BMI for age (percent of standard)**		
L **% Body Fat**		
M **Stride**	Total length of 5 steps: ___________________ Average stride length: ___________________	

Addendum 14: Reference list of various forms of physical activity for allocation of reported activities to appropriate activity levels

Level of physical activity	Type of physical activity
Resting	Sleeping and reclining
Very light	Seated and standing activities such as painting, typing, playing cards, playing a musical instrument, performing arts or singing.
Light	Walking on a level surface at 4.025 – 4.830 kilometers per hour, golf or table tennis
Moderate	Walking at 5.635 – 6.440 kilometers per hour, cycling, skiing, tennis, dancing, softball, gymnastics, karate, physical training (PT), or cricket.
Heavy	Basketball, climbing, soccer, running, rugby, swimming, or netball

Addendum 15: Pilot study daily check list for completion by all participants

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Did you remember to put your pedometer on this morning?					
Did you correctly place it on your hip bone as we discussed?					
Did you press **RESET** this morning when you put your pedometer on?					
Did you remember to press **STOP** each time you sat down today?					
Did you remember to press **START** each time you got up and started walking today?					
Did you remember to write down the number of steps you completed at the end of the school day today?					

Addendum 16: Ethics approval form with allocated project number

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot • your knowledge partner

17 August 2006

Ms A Philipou
Discipline of Human Nutrition
Dept of Interdisciplinary Health Sciences

Dear Ms Philipou

RESEARCH PROJECT: "TO DETERMINE THE EFFECT OF REGULAR INCREASED PHYSICAL ACTIVITY, AND REGULAR CONSUMPTION OF READY-TO-EAT-CEREAL (RTEC) BREAKFASTS AND AFTERNOON SNACKS, ON THE WEIGHT OF YOUNG ADOLESCENTS ATTENDING PUBLIC GAUTENG SCHOOLS"

PROJECT NUMBER : N06/07/139

It is my pleasure to inform you that the abovementioned project has been provisionally approved on 17 August 2006 **for a period of one year from this date**. You may start with the project, but this approval will however be submitted at the next meeting of the Committee for Human Research for ratification, after which we will contact you again.

Notwithstanding this approval, the Committee can request that work on this project be halted temporarily in anticipation of more information that they might deem necessary to make their final decision.

Please note that a progress report (obtainable on the website of our Division) should be submitted to the Committee before the year has expired. The Committee will then consider the continuation of the project for a further year (if necessary).

In future correspondence, kindly refer to the above project number.

Yours faithfully

CJ VAN TONDER
RESEARCH DEVELOPMENT AND SUPPORT (TYGERBERG)
Tel: +27 21 938 9207 / E-mail: cjvt@sun.ac.za

CJVT/cjvt

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Fakulteit Gesondheidswetenskappe • Faculty of Health Sciences

Verbind tot Optimale Gesondheid • Committed to Optimal Health
Afdeling Navorsingsontwikkeling en -steun • Research Development and Support Division
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E-pos/E-mail: rdsdinfo@sun.ac.za

Addendum 17: Descriptive depiction of the insignificant differences of the various variables of physical activity over the 5-week study period between the participants of the four study cohorts

	Total **n=119**	**Control** **(no intervention)** **n=31**	**Step** **(stepping intervention)** **n=29**	**RTEC** **(Ready-To-Eat cereal intervention)** **n=34**	**Step & RTEC** **(combined interventions)** **n=25**	**p-value**
Mean daily steps	82 803	83 501	77 258	86 082	83 911	p=0.47 (one-way ANOVA test)
SD	22 578	22 302	23 709	23 367	20 587	
CI	78 705–86 902	75 321-91 682	68 240-86 277	77 929-94 235	75 413-92 409	
Mean days of additional activities	12.67	14.90	11.04	13.18	11.12	p=0.12 (one-way ANOVA test)
SD	7.25	7.53	7.56	6.85	6.60	
CI	11.36-13.99	12.14-17.67	8.16-13.91	10.79-15.57	8.39-13.85	
Mean minutes of additional activity (very light intensity)	39.27	64.29	32.07	24.26	37.00	p=0.41 (Kruskal-Wallis test)
SD	128.35	180.13	127.77	91.44	93.27	
CI	15.97-62.57	-1.78-130.36	-16.53-80.67	-7.64-56.17	-1.50-75.50	
Mean minutes of additional activity (light intensity)	52.50	67.97	68.97	9.62	72.52	p=0.16 (Kruskal-Wallis test)

SD	147.49	186.15	155.04	35.09	173.91	
CI	25.72-79.27	-0.31-136.25	9.99-127.94	-2.66-21.86	0.73-144.31	
Mean minutes of additional activity (moderate intensity)	336.26	424.19	335.17	312.85	260.32	p=0.49 (one-way ANOVA test)
SD	406.00	470.56	434.44	373.57	323.76	
CI	262.56-409.96	251.59-596.80	169.92-500.42	182.51-443.20	126.68-393.96	
Mean minutes of additional activity (heavy intensity)	213.45	197.39	147.93	284.35	212.96	p=0.84 (Kruskal-Wallis test)
SD	381.61	302.86	200.74	549.77	355.09	
CI	144.18-282.73	86.30-308.48	71.57-224.29	92.53-476.18	66.39-359.53	
Mean days on which additional steps were completed		0	14.07	0	11.52	p=0.76 (pooled t-test)
SD		0	0.87	0	1.13	
CI		0	12.28-15.86	0	9.18-13.86	

Addendum 18: Descriptive depiction of the insignificant differences of the various variables of physical activity over the 5-week study period between the participants of the various final body mass index (BMI) classifications

	Total n=119	Normal (N) n=84	Overweight (V) n=24	Obese (B) n=11	p-value
Mean daily steps	82 803	83 695	80 628	80 736	p=0.80 (one-way ANOVA test)
SD	22 578	21 780	24 249	26 518	
CI	78705-86902	78969-88422	70389-90868	62 921-98 551	
Mean total steps	95 484	96 587	94 775	88 610	p=0.67 (one-way ANOVA test)
SD	28 101	27 919	27 050	33 203	
CI	90 383-100 586	90 529-102 646	83 353-106 197	66 304-110 916	
Mean days of additional activities	12.67	13.12	11.75	11.27	p=0.58 (one-way ANOVA test)
SD	7.25	6.84	8.37	8.04	
CI	11.36-13.99	11.64-14.60	8.21-15.29	5.87-16.67	
Mean minutes of additional activity (very light intensity)	39.27	46.01	28.13	12.09	p=0.83 (Kruskal-Wallis test)
SD	128.35	148.36	64.21	27.06	
CI	15.97-62.57	13.82-78.21	1.01-55.24	-6.09-30.27	
Mean minutes of additional activity (light intensity)	52.50	67.23	17.21	17.00	p=0.39 (Kruskal-Wallis test)

SD	147.49	169.64	61.60	54.10	
CI	25.72-79.27	30.41-104.04	-8.80-43.22	-19.35-53.35	
Mean minutes of additional activity (moderate intensity)	336.26	363.43	254.38	307.45	p=0.50 (one-way ANOVA test)
SD	406.00	418.40	323.96	476.98	
CI	262.56-409.96	272.63-454.23	117.58-391.17	-12.98-627.89	
Mean minutes of additional activity (heavy intensity)	213.45	188.02	316.25	183.36	p=0.77 (Kruskal-Wallis test)
SD	381.61	274.03	663.31	226.59	
CI	144.18-282.73	128.56-247.49	36.16-596.34	31.14-335.59	

Addendum 19: Descriptive depiction of the insignificant differences of the various variables of physical activity over the 5-week study period between the male and female participants of the study population

	Total n=119	Male n=82	Female n=37	p-value
Mean total steps	95 484	98 749	94 011	p=0.40 (pooled t-test)
SD	28 101	28 610	27 921	
CI	90 383-100 586	89 210-108 288	87 876-100 146	
Mean days of additional activities	12.67	12.08	12.94	p=0.55 (pooled t-test)
SD	7.25	7.88	6.98	
CI	11.36-13.99	9.45-14.71	11.41-14.47	
Mean minutes of additional activity (very light intensity)	39.27	1.62	56.26	p=0.09 (Mann-Whitney test)
SD	128.35	9.86	151.71	
CI	15.97-62.57	-1.67- 4.91	22.92-89.59	
Mean minutes of additional activity (light intensity)	52.50	27.30	63.87	p=0.17 (Mann-Whitney test)
SD	147.49	90.78	166.16	
CI	25.72-79.27	-2.97- 57.57	27.36-100.37	
Mean minutes of additional activity (moderate intensity)	336.26	411.95	302.11	p=0.43 (Mann-Whitney test)
SD	406.00	503.47	351.68	
CI	262.56-409.96	244.08-579.81	224.84-379.38	

Mean minutes of additional activity (heavy intensity)	213.45	214.30	213.07	p=0.99 (pooled t-test)
SD	381.61	376.91	386.01	
CI	144.18-282.73	88.63-339.96	128.26-297.89	

Addendum 20: Descriptive depiction of the insignificant differences of the various variables of Ready-To-Eat cereal (RTEC) consumption over the 5-week study period between the participants of the four study cohorts

	Total	Control (no intervention) n=31	Step (stepping intervention) n=29	RTEC (Ready-To-Eat cereal intervention) n=34	Step & RTEC (combined interventions) n=25	p-value
Mean days on which breakfast was consumed over 5-weeks	22.56	22.03	22.10	23.35	22.68	p=0.86 (Kruskal-Wallis test)
SD	3.69	4.87	4.05	2.17	3.21	
CI	21.89-23.23	20.25-23.82	20.56-23.64	22.59-24.11	21.35-24.01	
Mean servings of RTEC snacks consumed for breakfast over 5-weeks	0.66	0.16	0.59	0.97	0.96	p=0.09 (Kruskal-Wallis test)
SD	1.67	0.64	1.35	1.75	2.52	
CI	0.36-0.97	-0.07-0.40	0.07-1.10	0.36-1.58	-0.08-2.00	
Mean servings of RTEC consumed at times other than breakfast or afternoon snack over 5-weeks	0.38	0.77	0.17	0.18	0.40	p=0.23 (Kruskal-Wallis test)
SD	1.22	2.06	0.60	0.46	1.00	

CI	0.16-0.60	0.02-1.53	-0.06-0.40	0.02-0.34	-0.01-0.81	
Mean servings of RTEC consumed as morning snack over 5-weeks	0.04	0.03	0.00	0.09	0.04	p=0.50 (one-way ANOVA test)
SD	0.23	0.14	0.00	0.38	0.20	
CI	-0.00-0.083	-0.03-0.08	0.00	-0.04-0.22	-0.04-0.12	
Mean servings of RTEC consumed at lunch over 5-weeks	0.20	0.52	0.06	0.03	0.18	p=0.13 (Kruskal-Wallis test)
SD	0.77	1.33	0.24	0.17	0.63	
CI	0.06-0.34	0.03-1.01	-0.03-0.15	-0.03-0.09	-0.08-0.43	
Mean servings of RTEC consumed at dinner over 5-weeks	0.15	0.20	0.16	0.06	0.19	p=0.80 (Kruskal-Wallis test)
SD	0.68	0.77	0.84	0.24	0.78	
CI	0.03-0.27	-0.08-0.49	-0.16-0.47	-0.02-0.14	-0.13-0.52	
Mean servings of RTEC consumed as evening snack over 5-weeks	0.038	0.08	0.00	0.00	0.08	p=0.43 (one-way ANOVA test)
SD	0.26	0.37	0.00	0.00	0.40	
CI	-0.01-0.09	-0.05-0.22	0.00	0.00	-0.09-0.25	
Mean servings of RTEC	1.66	2.00	0.86	1.94	1.76	p=0.26 (Kruskal-

snacks consumed at times other than breakfast or afternoon snack						Wallis test)
SD	3.85	5.32	2.15	4.38	2.18	
CI	0.96-2.35	0.05-3.95	0.04-1.68	0.41-3.47	0.86-2.66	
Mean servings of RTEC snacks consumed as morning snack	0.76	1.35	0.21	0.82	0.60	p=0.62 (Kruskal-Wallis test)
SD	2.64	4.49	0.62	2.05	1.41	
CI	0.29-1.24	-0.29-3.00	-0.03-0.44	0.11-1.54	0.02-1.18	
Mean servings of RTEC snacks consumed at lunch	0.66	0.39	0.48	1.06	0.64	p=0.34 (Kruskal-Wallis test)
SD	2.41	0.80	1.70	4.06	1.19	
CI	0.22-1.09	0.09-0.68	-0.17-1.13	-0.36-2.48	0.15-1.13	
Mean servings of RTEC snacks consumed as evening snack	0.22	0.29	0.17	0.09	0.36	p=0.83 (Kruskal-Wallis test)
SD	0.73	0.86	0.66	0.29	0.99	
CI	0.09-0.35	-0.03-0.61	-0.08-0.42	-0.01-0.19	-0.05-0.77	
Mean total RTEC servings consumed over the 5-week study	19.56	17.11	18.78	21.30	21.14	p=0.07 (Kruskal-Wallis test)

period						
SD	9.06	10.31	12.25	5.70	5.97	
CI	17.92-21.20	13.33-20.89	14.12-23.44	19.31-23.29	18.67-23.60	

Addendum 21: Descriptive depiction of the insignificant differences of the various variables of Ready-To-Eat cereal (RTEC) consumption over the 5-week study period between the participants of the various final body mass index (BMI) classifications

	Total n=119	**Normal (N)** n=84	**Overweight (V)** n=24	**Obese (B)** n=11	**p-value**
Mean days on which breakfast was consumed	22.56	22.71	22.25	22.09	p=0.78 (one-way ANOVA test)
SD	3.69	3.46	4.45	3.94	
CI	21.89-23.23	21.96-23.46	20.37-24.13	19.45-24.74	
Mean servings of RTEC consumed at breakfast	18.56	18.75	17.29	19.85	p=0.68 (one-way ANOVA test)
SD	8.73	9.03	8.32	7.52	
CI	16.97-20.14	16.79-20.71	13.78-20.81	14.79-24.90	
Mean servings of RTEC snacks consumed at breakfast	0.66	0.62	0.75	0.82	p=0.90 (one-way ANOVA test)
SD	1.67	1.68	1.59	1.94	
CI	0.36-0.97	0.25-0.98	0.08-1.42	-0.49-2.12	
Mean days on which an afternoon snack was consumed	16.07	16.45	15.79	13.73	p=0.57 (one-way ANOVA test)
SD	8.14	8.22	8.29	7.50	
CI	14.59-17.55	14.67-18.24	12.29-19.29	8.69-18.76	
Mean servings of RTEC consumed as an afternoon	0.62	0.50	0.45	1.90	p=0.42 (Kruskal-Wallis test)

snack					
SD	1.89	1.55	0.75	4.35	
CI	0.28-0.97	0.17-0.84	0.14-0.77	-1.03-4.82	
Mean servings of RTEC snacks consumed as an afternoon snack	8.28	8.13	8.42	9.09	p=0.95 (one-way ANOVA test)
SD	9.30	9.48	8.80	9.72	
CI	6.59-9.97	6.07-10.19	4.70-12.13	2.56-15.62	
Mean total servings of RTEC consumed	19.56	19.66	18.08	22.02	p=0.49 (one-way ANOVA test)
SD	9.06	9.27	8.50	8.76	
CI	17.92-21.20	17.65-21.67	14.49-21.67	16.14-27.90	
Mean total servings of RTEC snacks consumed	10.60	10.44	10.63	11.73	p=0.92 (one-way ANOVA test)
SD	10.05	10.39	9.26	9.80	
CI	8.77-12.42	8.19-12.70	6.71-14.54	5.14-18.31	

Addendum 22: Descriptive depiction of the insignificant differences of the various variables of Ready-To-Eat cereal (RTEC) consumption over the 5-week study period between the male and female participants of the study population

	Total n=119	**Male** n=82	**Female** n=37	**p-value**
Mean days on which breakfast was consumed	22.56	23.19	22.28	p=0.53 (Mann-Whitney test)
SD	3.69	2.40	4.13	
CI	21.89-23.23	22.39-23.99	21.37-23.19	
Mean servings of RTEC consumed at breakfast	18.56	19.95	17.93	p=0.25 (pooled t-test)
SD	8.73	7.54	9.19	
CI	16.97-20.14	17.43-22.46	15.91-19.95	
Mean servings of RTEC snacks consumed at breakfast	0.66	0.81	0.60	p=0.90 (Mann-Whitney test)
SD	1.67	2.08	1.46	
CI	0.36-0.97	0.12-1.50	0.28-0.92	
Mean days on which an afternoon snack was consumed	16.07	15.43	16.35	p=0.57 (pooled t-test)
SD	8.14	8.49	8.02	
CI	14.59-17.55	12.60-18.26	14.59-18.12	
Mean servings of RTEC consumed as an afternoon snack	0.62	0.34	0.75	p=0.25 (Mann-Whitney test)
SD	1.89	0.88	2.20	
CI	0.28-0.97	0.04-0.63	0.27-1.23	
Mean servings of RTEC snacks	8.28	8.65	8.11	p=0.77

consumed as an afternoon snack				(pooled t-test)
SD	9.30	9.61	9.21	
CI	6.59-9.97	5.44-11.85	6.09-10.13	
Mean total servings of RTEC consumed	19.56	20.55	19.11	p=0.42 (pooled t-test)
SD	9.06	7.68	9.63	
CI	17.92-21.20	17.99-23.11	17.00-21.23	
Mean total servings of RTEC snacks consumed	10.60	10.86	10.48	p=0.85 (pooled t-test)
SD	10.05	10.31	9.99	
CI	8.77-12.42	7.43-14.30	8.28-12.67	

Addendum 23: Descriptive depiction of the insignificant differences of the various anthropometric variables at the start of the 5-week study period across the four cohorts

	Total	**Control** (no intervention) n=31	**Step** (stepping intervention) n=29	**RTEC** (RTEC intervention) n=34	**Step & RTEC** (combined interventions) n=25	**p-value**
Mean baseline body weight	47.24	46.26	47.22	48.01	47.42	p=0.95 (one-way ANOVA test)
SD	12.03	12.66	12.28	12.08	11.51	
CI	45.05-49.42	41.62-50.91	45.05-49.42	43.79-52.22	42.67-52.17	
Mean baseline percentage body fat	23.66	22.86	24.59	22.56	25.04	p=0.63 (one-way ANOVA test)
SD	8.71	9.65	8.75	8.59	7.76	
CI	22.08-25.24	19.32-26.40	21.27-27.92	19.56-25.55	21.84-28.25	

Addendum 24: Descriptive depiction of the insignificant changes in the various anthropometric variables over the 5-week study period across the four cohorts

	Total	Control (no intervention) n=31	Step (stepping intervention) n=29	RTEC (Ready-To-Eat cereal intervention) n=34	Step & RTEC (combined interventions) n=25	p-value
Mean change in weight	-0.07	0.04	0.08	-0.24	-0.12	p=0.35 (one-way ANOVA test)
SD	0.79	0.84	0.75	0.77	0.81	
CI	-0.21-0.08	-0.27-0.34	-0.21-0.37	-0.51-0.02	-0.46-0.21	
Mean change in body mass index (BMI)	-0.15	-0.06	-0.07	-0.28	-0.17	p=0.09 (one-way ANOVA test)
SD	0.40	0.39	0.39	0.40	0.38	
CI	-0.22- -0.08	-0.20-0.08	-0.22-0.08	-0.42- -0.14	-0.33- -0.01	
Mean change in percentage body fat	-0.23	-0.08	-0.32	-0.28	-0.22	p=0.47 (Kruskal-Wallis test)
SD	1.09	1.04	0.70	1.39	1.12	
CI	-0.43- -0.03	-0.47-0.30	-0.59- -0.06	-0.76-0.21	-0.68-0.24	
Mean change in kilograms of body fat	-0.15	-0.08	-0.16	-0.20	-0.17	p=0.65 (Kruskal-Wallis test)
SD	0.66	0.60	0.43	0.83	0.73	
CI	-0.27- -0.03	-0.30-0.14	-0.32-0.00	-0.49-0.09	-0.47-0.12	

Addendum 25: Descriptive depiction of the insignificant changes in the various anthropometric variables over the 5-week study period between the participants of the various final BMI classifications

	Total n=119	**Normal (N)** n=84	**Overweight (V)** n=24	**Obese (B)** n=11	**p-value**
Mean change in weight	-0.07	-0.02	-0.16	-0.19	p=0.65 (one-way ANOVA test)
SD	0.79	0.71	1.01	0.94	
CI	-0.21-0.08	-0.18-0.13	-0.59-0.26	-0.82-0.44	

Addendum 26: Descriptive depiction of the insignificant changes in the various anthropometric variables over the 5-week study period between the male and female participants of the study population

	Total n=119	Male n=37	Female n=82	p-value
Mean change in body weight	-0.07	-0.17	-0.02	p=0.36 (pooled t-test)
SD	0.79	0.76	0.81	
CI	-0.21-0.08	-0.42-0.09	-0.20-0.16	
Mean change in body mass index (BMI)	-0.15	-0.19	-0.13	p=0.39 (pooled t-test)
SD	0.40	0.38	0.41	
CI	-0.22- -0.08	-0.32- -0.07	-0.22- -0.04	