Novel software to reduce the risk of energy related illnesses

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ABSTRACT

People often neglect their diets because of the effort required to ensure that they are maintaining a healthy diet. Most people do not know exactly what types of food and the amount they should eat without some guidance. The ideal would be to provide them with an assistant who could supply the required information quickly and reliably when needed.

Diabetes and obesity are serious illnesses that are on the increase worldwide. Both these illnesses are related to food consumption and are referred to as energy related illnesses. Human beings derive energy from the food that they consume and thus it is of the utmost importance that they follow a healthy diet. The latter should ensure that the correct amount of energy is obtained and used on a daily basis.

At Human-Sim (Pty) Ltd a new method for quantifying the energy available from food has been developed known as the Equivalent Teaspoon Sugar (ets). By using ets a healthy diet can be established for both healthy individuals and those suffering from diabetes or obesity.

This study investigates the feasibility of providing an individual with a digital assistant to help with maintaining a healthy diet. The assistant is implemented on a cellular phone platform to ensure the least inconvenience to the user. The study also investigates the efficiency of the ets concept for dietary energy control.

The results obtained during this study showed that the dietary assistant was successful. The user acceptance was high and the efficiency of use impressive. Users found it easy and intuitive to relate to the new ets quantification method.

SAMEVATTING

Dit is in die geaardheid van mense om hul dieet te verwaarloos omdat dit baie keer moeilik en harde werk is om tret te hou met 'n gesonde dieet. Meeste mense weet nie van die staanspoor af watter kos en hoeveel daarvan om te eet om 'n gesonde dieet te volg nie. Die ideal sal wees om vir die mense 'n assistent te gee om die nodige inligting vir hulle vinnig en eenvoudig te verskaf.

Diabetes en obisiteit is wêreldwye siektes wat aan die toeneem is. Beide van die siektes is gekoppel aan die inname van voedsel. Hierdie siektes word na verwys as energie verwante siektetoestande. Menslike energie is afkomstig van kos wat gebruik word en dus is dit van uiterste belang dat 'n gesonde dieet gevolg moet word. 'n Gesonde dieet sal verseker dat die regte balans tussen energie inname en energie verbruik gehandhaaf word.

By Human-Sim (Pty) Ltd is 'n nuwe metode ontwikkel vir die kwantifisering van die energie inhoud in voedsel. Hierdie metode staan bekend as die Ekwivalente Teelepels Suiker (ets). 'n Gesonde dieet kan vanaf die ets metode afgelei word vir beide gesonde mense en mense met siektetoestande wat 'n spesiale dieet moet volg.

Hierdie studie ondersoek die moontlikheid daarvan om 'n elektroniese assistent aan 'n persoon te verskaf om te help met die volhouding van 'n gesonde dieet. Die assistent is op 'n sellulêre telefoon geimplementeer. Hierdie studie ondersoek ook die effektiwiteit van die ets metode vir energie beheer.

Die resultate wat gedurende hierdie studie ingesamel is dui daarop dat die dieet-assistant 'n groot sukses is. Die gebruiker se aanvaarding van die assistent was goed en die effektiwiteit van gebruik hoog. Die gebruikers het dit ook maklik gevind om die nuwe ets-konsep te aanvaar.

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NOMENCLATURE

ABBREVIATIONS

AUC	Area Under the Curve
AUCI	Area Under the Curve of Insulin
BMI	Body Mass Index
BS	Blood Sugar
CDC	Centre for Disease Control and Prevention
CHO	Carbohydrate
ETS	Equivalent Teaspoon Sugar
FU*x*	Functional Unit *x*
GI	Glycaemic Index
GL	Glycaemic Load
GUI	Graphical User Interface
IBS	Insulin/Blood Sugar relationship
J2ME	Java Mobile Edition
RDA	Recommended Daily Allowance
USA	United States of America

SYMBOLS

AUC_{BS}	Area under the curve of blood sugar response

AUC_{Food}	Area under the curve of the food being tested
AUC_I	Area under the curve of insulin response
$AUC_{Ingested}$	Area of the blood glucose response curve of ingested glucose
$AUC_{Injected}$	Area of the blood glucose response curve of injected glucose
$AUC_{Reference}$	Area under the curve of the reference food in the test
ΔBS_{Rise}	Absolute rise in blood sugar concentration due to an ingested meal
ΔBS_{Fall}	Absolute drop in blood sugar concentration due to injected (or secreted) insulin
$BI(t)$	Blood insulin response
$BS(t)$	Blood sugar response.
$BS_{Blood(t)}$	Blood sugar concentration at a specific time
E_{Absorb}	Total amount of energy absorbed into the bloodstream
E_{CHO}	Converted carbohydrate energy potential
E_{ets}	Total amount of blood glucose energy available from ingested ets
$E_{Expended}$	Total amount of energy expended by the body
$E_{Expended(RDA)}$	Total recommended amount of energy to be expended daily
$E_{Ingested}$	Energy extracted from ingested food
E_{Liver}	Energy extracted from the liver store
E_{RDA}	Total amount of daily energy required
E_{Stored}	Energy retrieved from glucose energy stores
$E_{teaspoon\ sugar}$	Energy available from a teaspoon of sugar
ets	Equivalent teaspoons sugar

ets_{Actual}	Actual amount of ets consumed in a meal
ets_{RDA}	Recommended daily allowance of equivalent teaspoons sugar
ets_{Total}	Total amount of ets for which long-acting insulin has to be injected
f_{AUCI}	Insulin response area / ets relationship efficiency factor
f_{CHO}	Efficiency factor for converting ingested carbohydrates into blood sugar energy
$f_{Expended}$	Efficiency factor for converting ingested ets into expendable blood glucose energy
f_I	Insulin response / ets relationship efficiency factor
f_{IBS}	Insulin / blood sugar relationship efficiency factor
f_{Ingest}	Efficiency factor for extracting energy from ingested food
G_{Basal}	Amount of basal energy required
G_{Blood}	Blood glucose concentration
GI_{CHO}	Conversion potential of energy from ingested food (approximated with GI)
GI_{sugar}	Conversion potential of energy from sugar
I_{Basal}	Basal insulin level
$I_{Control}$	Amount of regulation hormone in the system
$I_{Injected}$	Short-acting insulin requirement
$I_{Injected(Long)}$	Long-acting insulin requirement
$I_{Secreted}$	Amount of insulin secreted
K	Blood sugar / ets conversion factor

k_{CHO}	Maximum amount of energy available from carbohydrates
L	Length
m_{CHO}	Mass of carbohydrates contained in the food
$m_{teaspoon\ \ sugar}$	Mass of carbohydrates contained in a teaspoon of sugar
Δt	Time elapsed between consumption and restoration of basal level
t	Time
V_{Blood}	Volume of blood of a person
W	Weight

UNITS

dl	Decilitre
ets	Equivalent Teaspoons Sugar
g	Grams
kCal	Kilocalories
kg	Kilograms
KJ	Kilojoules
l	Litre
mmol	Milli-mol
mg	Milligram
unit(s)	Insulin units

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CHAPTER 1

INTRODUCTION

1.1 PREAMBLE

Diabetics must exercise control over their blood sugar levels. Blood sugar is controlled through correct diet, exercise and diabetic medication. Diabetics therefore need to know what are the correct food choices and why. Sports persons need to know how diet influences their performance [1]. Obesity is a serious illness directly linked to dieting and has become a major concern in modern times. Thus, it is important for people to take control of their weight through the correct diet and exercise.

People often tend to neglect their diet because of the effort it requires to ensure that they are keeping track with what is a healthy diet in their case. Few people know exactly what types of food they should eat and how large portions sizes should be. The ideal would be to provide these people with an assistant who could supply them with the required information quickly and reliably when needed.

1.2 BACKGROUND

1.2.1 THE HUMAN ENERGY SYSTEM

The behaviour of the human body is often compared to that of a machine or engine [1]. The body takes an energy input and converts that energy into different forms such as mental and physical energy just like an engine would convert fuel to mechanical energy. However, unlike a mechanical machine, the human body has the advantage of repairing and regenerating itself. This unique attribute does require the mobilization and sustaining of internal processes for self-preservation [2].

The functioning of the human body may appear a difficult and sometimes impossible task to cope with when viewed from a physiological or biochemical perspective. Much remains unknown of the nature of all the biochemical processes in the human body. It is still an ongoing process to learn all there is to know about the human machine [2].

It is possible to describe the human body by means of distinct energy pathways and controls. A major problem has been the quantification of the energy flow. One of the latest and promising techniques is known as ets [3]. Greater detail on ets will be given later.

The human engine uses glucose in the blood circulation system as one of its primary sources of energy. Glucose is obtained mainly through the consumption and digestion of food and from the stored reserves in the body [4]. Control of the flow of energy through the system is a complex matter and is mainly accomplished by means of endocrine regulation and concentration imbalance between the system components [5].

The human body needs a constant supply of energy input to sustain itself and keep its processes going. Similar to mechanical engines, fuel shortage presents a problem for the human body and may result in starvation, underperformance and even cessation. Over supply is also not a good condition for either the human or mechanical engine as it may flood and damage the engine [5].

The human body regulates its fuel in the blood system without conscious intervention from most normal healthy individuals. Special performance requirements, residue build-up and malfunctioning of the regulatory systems have been the catalysts for enormous amounts of research during the past few years. Much has been learned, but indications are that in all probability a substantial amount still awaits discovery and understanding [5].

1.2.2 DIABETES MELLITUS

Blood glucose is regulated by two mechanisms which maintain glycaemic homeostasis [6]. These regulation mechanisms actively monitor the blood glucose concentrations and react to external disturbances [7]. Through the control of the blood glucose concentrations at the desired level all the other energy system components can function correctly.

The two control mechanisms are referred to as the regulation and counter regulation systems [7]. Whenever the blood glucose concentration falls below a certain threshold, the counter regulation system activates a number of glands, which secrete certain hormones (e.g. glucagon, cortisol, adrenalin) into the bloodstream. These hormones then activate the energy storage cells in the body to release glucose into the bloodstream and the desired blood glucose level is restored [5].

Whenever the blood glucose level rises too high, the regulation system activates the pancreas to secrete the hormone insulin. The primary function of insulin is to activate cellular uptake of available blood glucose. By absorbing the excess glucose in the bloodstream into the storage cells, the desired blood glucose concentration is restored [8].

The control system may malfunction. Diabetes mellitus is the most common malfunction of the blood glucose regulation system. Diabetes is the condition where the pancreas either fails to produce insulin (Type 1) or the person becomes resistant to insulin (Type 2) and thus inhibits the regulation system to lower blood glucose levels. High blood glucose concentrations (hyperglycaemia) hold many health complications. Therefore, a diabetic sufferer must administer insulin or take medication to control his/her blood glucose level. Even more dangerous is a too low blood glucose level (hypoglycaemia).This condition can lead to loss of consciousness and in severe cases even death [5].

It is not easy to control blood glucose levels accurately [9]. Diabetes is currently reaching epidemic proportions. There are currently estimated to be 110 million diabetes sufferers around the world. This number is expected to double by the year 2010 and, if no cure can be found, it can increase to 300 million by 2025 [10],[11]. Of these about 30 million are insulin dependant and have to inject insulin on a daily basis [8].

Studies from the USA have shown an increase in the occurrence of Type 2 diabetes in the younger population [12]. During 1990 to 1998 the prevalence of diabetes increased by 33% throughout the whole population of the United States of America (USA). Most alarmingly, the prevalence in individuals from age 30 to 39 years increased by 70% [13]. The total increase in diabetes since 1990 is estimated at 49% [14].

In total there are currently 16 million diabetics in the USA and diabetes is the third largest cause of death [15]. This is an outright epidemic with a significant impact on the worldwide economy [16]. The USA has an estimated expenditure of between $92 billion and $103 billion annually to combat the disease [15].

1.2.3 DIABETIC INSULIN REQUIREMENT

Type 1 diabetes mellitus is a condition in which the patient's pancreas does not produce any (or adequate amounts) of insulin for glycaemic control [1]. The insulin therefore has to be administered manually on a regular basis. Type 1 diabetics usually find it relatively difficult to control their blood sugar levels due to the uncertainties associated with insulin requirement.

In most control a basal-bolus regime is used. Two types of insulin are injected namely long-acting (basal) and short-acting insulin (bolus) [2].

The purpose of the long-acting insulin is to mimic the basal insulin level a healthy person normally has in his / her blood. The insulin is usually administered once (or twice) daily and the effective release of insulin from the injection into the bloodstream occurs gradually but continuously throughout the day. Basal insulin allows cells in the human body to utilize glucose for their energy needs.

Because a constant release of insulin is essential to mimic a healthy person's basal level, the best type of insulin for a long-acting effect is obviously one with a constant release profile [2], [4]. Today two types of insulin adheres sufficiently to this specification, namely Lantus and Levemir manufactured by Aventis and Novo Nordisk respectively [5]. Basal insulin activity can also be controlled by using an insulin pump that allows precise control over the insulin release rate.

Short-acting insulin on the other hand is required to lower intermittent and irregular elevations in blood glucose concentration. These elevations may occur due to a number of disturbances of which carbohydrate (CHO) ingestion is the most common. The short-acting insulin activates the storage cells in the human energy system to absorb the extra available blood sugar and hence regulates the glycaemic response. This is the reason why it is called storage insulin and why it is usually injected in conjunction with meals [2].

Walsh et al as well as a number of other researchers suggest that the total daily dosages of long-acting and short-acting insulin should be equal [2]. In other words, the sum of all short-acting insulin dosages administered to regulate ('store') each meal should be equal to the sum of the long-acting insulin dosages for each day.

However, a common mistake made by diabetics (and their medical advisors) is to inject too little long-acting insulin. The result is blood sugar levels that gradually keep rising throughout the day. The patient then has to inject more short-acting insulin to lower the high concentrations of blood glucose. However, because the effect of the short-acting insulin is exhausted relatively quickly, the blood sugar levels again start to rise and another injection is required. The result is an undesirable seesaw glycaemic response. Furthermore such diabetic patients are also more susceptible to hypoglycaemic excursions.

1.2.4 OBESITY

Obesity can be defined as "excess adiposity for a given body size" [17]. The International Obesity Task Force has defined being 'overweight' as having a Body Mass Index (BMI) of more than 25 kg/m^2 and being 'obese' as having a BMI of more than 30 kg/m^2. The criteria determine that 55% of the adult population in the USA is overweight and 22.5% is obese [18]. A South African study performed by Mollentze et al confirmed a similar problem in 1995 in this country. It showed that the overall average BMI of women in rural areas of South Africa was above 25 kg/m^2 [19].

Obesity is a major health problem [19],[20]. Costs attributable to obesity totalled $99.2 billion in the United States in 1995 of which more than half was associated with medical expenditure [21]. The occurrence of obesity has increased by 61% since 1991. Continuing on the current trend, the Centre for Disease Control and Prevention (CDC) states that the health care costs will be staggering in future [14].

The hormone insulin is the major role-playing agent in human energy storage control [8],[22]. A direct link therefore exists between adipose tissue growth (gaining weight) and disorders regarding insulin [22]. This is the reason for obesity being associated with conditions like glucose intolerance, hyperinsulinemia, dyslipidemia, insulin resistance and diabetes mellitus [17],[23],[24],[25].

1.3 PROBLEM ADDRESSED

The problem addressed in this study is the development of a cellular phone based dietary assistant. The assistant provides the user with the necessary information to help with an enegry restricted diet to assist the user with managing his/her weight and reducing the diabetes risk by means of the corrective measures relating to food intake and exercise done by the user. The dietary assistant must be user-friendly and easily accessible at anytime the user requires it.

The dietary assistant is based on the method developed by Mathews and Botha [3]. By using this method the accuracy of the measurements and information given by the dietary assistant should be greatly improved [3].

1.4 STUDY OBJECTIVES

The objectives of the study are the following:

- Show the effectiveness of the ets dietary concept through limiting energy intake. This objective will be proven by a weight loss experiment.

- To provide a practical implementation of the dietary assistant. This application must provide accurate and useful information.

- Show the user acceptance of the dietary assistant. Through using the dietary assistant users will provide feedback of their personal experience.

1.5 STUDY METHOD EMPLOYED

A thorough literature survey led to the concept on which the assistant was based. The literature survey served to illustrate the need for people to be conscious about their health.

Work done by Prof E.H. Mathews and Dr C. Botha to develop the method used for the simulation model of the human body's response to different foodstuff and exercise routines was used as the basis for the dietary assistant.

With the help of Dr P. Ackerman a study was done on the effect that a limited ets diet had on his patients. The results of this study is used to show the effectiveness of the ets concept in limiting energy intake.

The dietary assistant was implemented on a popular cellular phone and handed to a number of users to evaluate. Users were asked to complete a questionnaire to the effect of illustrating the users' perceptions of the dietary assistant.

CHAPTER 2

NEW QUANTIFICATION OF CARBOHYDRATE ENERGY

2.1 MEASUREMENT OF ENERGY IN FOOD

2.1.1 CARBOHYDRATE COUNTING

Healthy individuals as well as people suffering from diabetes mellitus often use carbohydrate counting as a meal planning method [26]. The technique focuses on CHO as the primary nutrient affecting postprandial (after a meal) glycaemic response [27]. This idea stems from the late 1920's and received renewed interest after the Diabetes Control and Complications Trial [28],[29],[30]. In the trial, carbohydrate counting was found to be the most effective in meeting outcome goals and allowed flexibility in food choices.

Recently surveys have shown that the interest in using carbohydrate counting for medical nutrition therapy by both diabetics and healthy people is on the increase [31],[32]. Gillespie et al conducted research on this subject and identified three distinct levels of carbohydrate counting based on increasing levels of complexity [31]. People are taught how to count their CHO ingestion using these levels.

- Level 1 (basic counting) introduces diabetes patients to the concept of carbohydrate counting and focuses on carbohydrate consistency.

- Level 2 (intermediate counting) focuses on the relationships among food, diabetes medications, physical activity, and blood glucose levels. It also introduces the steps needed to manage these variables based on patterns of blood glucose responses.

- Level 3 (advanced counting) is designed to teach clients with Type 1 diabetes who are using multiple daily injections or insulin infusion pumps how to match short-acting insulin to carbohydrates using carbohydrate-to-insulin ratios.

Portion-control is emphasized at all three levels. This approach offers opportunities for using creative teaching methods, such as a variety of carbohydrate resource tools and publications. None of the three levels references the type of carbohydrates consumed.

Carbohydrate counting is simply done by measuring and restricting the total amount of dietary CHO in a meal.

The glycaemic response from consuming a meal can be significantly effected by the type or building blocks of the ingested CHO. Dietary carbohydrates consist of three major 'building blocks' or monosaccharides. The three building blocks are glucose, fructose and galactose. When these carbohydrates are combined, the secondary 'building blocks' or disaccharides are formed. These are sucrose (combination of fructose and glucose) and lactose (combination of galactose and glucose), which are also the most commonly found CHO in normal diets [33].

Carbohydrates may be more complex and are made up of combinations of monosaccharides, these are known as oligosaccharides. These include the a-galactosides, the fructo- and the malto-oligosaccharides. There are also some other types of CHO, like polysaccharides that can be further subdivided into the starchy and non-starchy polysaccharides. Because of the differences in the CHO, each of these has a variable digestibility and therefore has a higher or lower impact on glycaemic response [33],[34].

When carbohydrates are ingested, the digestive tract, including both the small and the large intestines, breaks down (or hydrolyses) the CHO into the simplest form, namely the monosaccherides (glucose, fructose and galactose). These are then transported to the liver through the portal vein where the monosaccherides are converted into glucose. Some of the glucose is then released into the bloodstream invariably causing the blood sugar levels to rise [35].

It is because of this rise in blood sugar levels that diabetics must inject insulin as a regulatory control. A person makes an estimate of the amount of insulin to inject based on the CHO amount consumed, by using the CHO counting method [36],[37]. Some success has been obtained, however some limitations of this method have been identified.

2.2.2 LIMITATIONS CONCERNING CARBOHYDRATE COUNTING

Using the method of carbohydrate counting has greatly enabled glycaemic control for people diagnosed with Type 1 diabetes mellitus. However, the method has a few limitations.

There are certain questions that arise regarding the use and applicability of CHO counting.

- How much CHO is contained in food?
- Does the method work?
- How much carbohydrate can be prescribed to a person?
- How does one balance the diet with fat and protein?
- Which patients are the best candidates for carbohydrate counting? [38]

In an article written by Gregory and Davis possible answers are provided to these questions based on clinical experience at the Vanderbilt University Medical Centre, Diabetes Research and Training Centre, and the Diabetes Control and Complications Trial [38]. They acknowledge that carbohydrate counting is not easily comprehensible for any individual. Food composition tables are not always available and the values surrounding the amount of CHO in a particular food are normally high, which makes calculations using these values difficult.

There are a large number of different types of CHO, and they all produce different glycaemic responses. The methods currently just total the CHO content of the meal and predict an insulin dosage accordingly.

2.1.3 GLYCAEMIC INDEX

In essence the GI of a particular foodstuff relates to the glycaemic response or rise and fall of blood sugar level its ingestion induces. Only foods that contain carbohydrates induce a significant rise in blood sugar levels in human beings. Neither pure protein nor pure fat has any substantial impact on blood glucose levels [39].

Glycaemic index of food ranks the food on its short-term effect on blood-sugar levels. To make a fair comparison, all foods are compared with a reference food and are tested in equal carbohydrate amounts. The standard against which GI is measured is 50g of carbohydrate in the form of pure glucose. This 'reference' amount is assumed to be the relative value of 100 [40].

Another reference used is 50g of carbohydrate in the form of white bread as 100 [40]. The use of the two standards has caused some confusion but it is possible to convert from one to the other by simply multiplying with a factor of 1.4. (Glucose has a GI value of 140 when white bread is the reference food. Alternatively, if the reference food is white bread, the GI of the food should be divided by 1.4 to find the GI referenced to pure glucose.) For the purpose of this study, glucose was used as the reference standard.

The following method is used to measure GI: A healthy person must fast for at least six to ten hours prior to performing the test. Fasting ensures that any traces of glucose and effects of previous meals are negligible.

The reference food is ingested. For the glucose reference 50g of pure glucose is used. Over the next two hours, blood samples are taken at 15-minute intervals during the first hour followed by two 30-minute intervals for the remaining hour. Blood sugar levels of the samples are measured in the laboratory and recorded. The result is a graph of blood sugar level plotted against elapsed time.

After a similar fasting period the procedure is repeated. Instead of ingesting pure glucose, the food for which the GI has to be calculated is eaten. The amount of food that has to be taken has to be the amount that contains exactly 50g of carbohydrates. (In the case of potatoes, for example, 250g potatoes is required because that portion will yield 50g of carbohydrates.) Again the blood sugar measurements are taken as described for the reference food.

GI is defined as the ratio (percentage) between the glycaemic responses of the measured food and the reference food. To relate the responses, the area under the curves (AUC) are calculated for each test and compared by dividing the AUC of the test food by the AUC of the reference food. The calculation of the AUC for one of the tests is graphically presented in Figure 2.1.

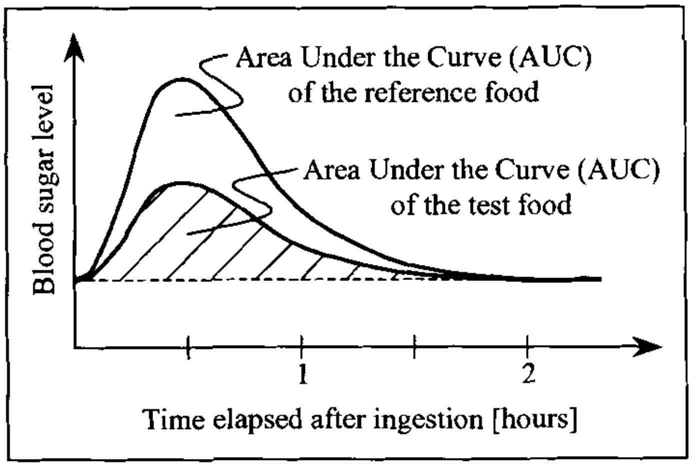

Figure 2-1 Measurement of AUC of the glucose response due to ingested CHO in order to determine the GI of the test food

The test is repeated a number of times with different test subjects and an average value is found. To find the GI, the AUC of the test food is expressed as a percentage of the AUC of the reference food. Equation (2.1) shows the final calculation of GI where AUC_{Food} is the area under the glucose response curve of the food in question (the test food) and $AUC_{Reference}$ is the area under the glucose response curve of the reference food (in this case, pure glucose).

$$GI = \frac{AUC_{Food}}{AUC_{Reference}} \tag{2.1}$$

GI factors determined for different foods have been found to be mostly repeatable per individual and thus are useful when selecting carbohydrate food for glycaemic control.

The concept has, however, received considerable criticism, which is discussed in the following section [41].

2.1.4 LIMITATIONS CONCERNING GI

The application of GI presents a few problems:

- GI values alone are not easily applied to meal planning and thus do not provide a practical application platform for its use. This is because GI values are not related to food portion sizes. It is a property of the food but not the amount of the food.

- Many food manufacturers and producers oppose GI labelling of foods because many consumers perceive high GI values as negative and therefore undesirable. GI alone is not the determining factor for blood sugar response. In many cases the amount of food consumed has more to do with glycaemic response than it has with the type of CHO that is ingested.

  For example, a 1.3 kg watermelon, which contains only 8g of carbohydrate per 150 g serving, must be consumed to produce the same glycaemic response as 50g of glucose powder. Watermelon has a high GI value of 72 and as such may be considered unhealthy by some people. But, since the CHO content of watermelon is relatively small, a normal sized portion would produce totally acceptable blood sugar levels [40].

- Measurements are taken from a number of different individuals to determine their average glycaemic responses and GI values are based on these measurements. This presents a problem as there are often large variations in the measurements. Many regard average GI values as unscientific and of little value to general dietary planning and management. The reasons for the variances are not yet described to scientific satisfaction, and may be attributable to a host of metabolic and biochemical factors. The glycaemic response to GI-measured food yields acceptable repeatable results for individual test subjects.

GI values provide some indication of relative variances to be expected when determining glycaemic response or energy utilisation in the human body. GI values therefore have a valid role to play in nutritional management. In the following sections the specific role that GI can play are discussed in more detail.

2.1.5 GLYCAEMIC LOAD

Because of its limitations the glycaemic index has received much criticism throughout the literature. In response to these negative comments, Brand Miller published an article to highlight the advantages of the index in an attempt to counter some of the criticism [4]. She states that: "It (GI) was never intended to be used in isolation". This comment was in response to a statement that GI should not be used due to the negative connotations linked to certain foodstuffs [41].

The amount of CHO that was associated with those foods was not considered. For example, it might be perceived that cola, with a GI of 64, is 'better' for human consumption (will induce a lower glycaemic response) than cranberry juice, with a GI of 75, because of the lower GI. Similarly people might want to eliminate carrots from their diets because of the extremely high GI of 93 [40].

If common sense should prevail, it would be obvious that cranberry juice should be 'healthier' than cola and that carrots cannot be 'unhealthy'. The reason for this common misconception is that the amount of CHO that is consumed in normal portions of the food is not taken into account when comparing the foods [42]. Using GI in isolation will only be applicable if foods are considered that contain equal amounts of CHO.

To relate foods with varying amounts of CHO Salmerón et al introduced a novel dietary variable termed 'glycaemic load' [43]. The glycaemic load (GL) of a food is defined as the product of the glycaemic index (GI) value of the food and the carbohydrate content of the portion that is considered (m_{CHO}). This calculation is shown in equation (2.2).

$$GL = GI.m_{CHO} \tag{2.2}$$

In the example above a normal portion of carrots, for example, contains 5g of CHO. The glycaemic load of the portion of carrots is then $GL = GI.m_{CHO} = (93\%)(5) = 4.7$. The comparison between the cola (m_{CHO} =51, GL =32.8) and the cranberry juice (m_{CHO} =15, GL =11.3) yields that cranberry juice is indeed the 'better' choice if glycaemic response is to be limited.

Many studies have established the link between the glycaemic load and diseases, abnormalities and health risks [43]. The concept has not yet publicly been accepted as the general criterion for ranking of different foods. This might be due to the difficulty of having to memorise both GI values and CHO content of foods.

In the next sections a new approach is presented based on a similar argument as the glycaemic load. However, the new approach is aimed at ease-of-use as well as accuracy of glycaemic prediction.

2.2 ENERGY FROM INGESTED CARBOHYDRATES

When oxidised in pure oxygen, measurements with a bomb calorimeter suggest that 4kCal/g of energy can be released from CHO [44]. The human energy system does not use the same process for energy conversion as a bomb calorimeter. The bomb calorimeter method uses the optimum method for extracting energy from food. It can be assumed that the human body does not use the same optimum method. For instance, the human body does not convert CHO in energy in pure oxygen and not all of the CHO is converted, as is the case for the bomb calorimeter. It is therefore necessary to investigate how much energy the human energy system actually does convert.

The processes in the human body are integrated and very complex, which makes it difficult to measure the conversion process. However, it is well known that the energy extracted from ingested CHO is converted into useful blood sugar energy [45]. But, it is also fairly difficult to measure the amount of blood sugar energy in healthy people. Insulin enables the storage and utilisation of blood sugar energy during the conversion process [37]. A possible method would be to integrate the blood sugar response curve over time, account for blood volume and time from ingestion to reaching basal blood sugar again, and hence find a fair approximation of this converted energy.

However, as this is too difficult, a simpler way is proposed by Botha [3]. Type 1 diabetics have no or negligible insulin secretion. Without insulin, the blood sugar energy released through digestion cannot be stored or utilised during the conversion process [37]. This condition simplifies the measurements. The level to which diabetics' blood sugar levels rise should therefore give a good measure of the amount of blood sugar energy converted from the ingested CHO.

A Type 1 diabetic's blood sugar levels can be measured after ingesting the same amount of two different types of CHO, on two separate occasions. (One of the foods is used as a reference.) As an example the person can ingest an equal amount of glucose and fructose. If all the possible energy (4 kCal/g) were made available from the digestion process, the similar blood glucose responses would be the expected result.

A series of empirical measurements, shown schematically in Figure 2.2, illustrates a trend that is different from this expected result. Blood sugar response to glucose and thus the conversion of glucose into blood sugar energy are approximately four times more efficient than fructose. The subsequent question is: How can the energy available after conversion for any other type of carbohydrate be calculated?

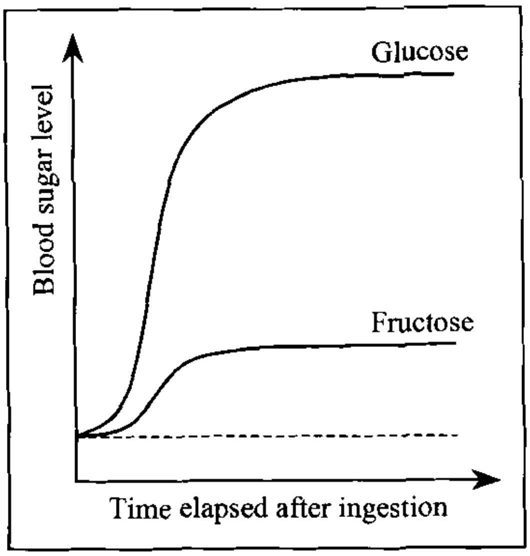

Figure 2.2 – Schematic representation of measurements of blood sugar response when a Type 1 diabetic eats equal amounts of CHO contained in glucose and fructose

The Glycaemic Index (GI) of glucose is 100. This is approximately four times greater than that of fructose, which is only 23 [40]. Therefore, GI actually gives an idea of the energy conversion potential of the carbohydrates under investigation.

The definition of GI states that GI is the rate of absorption for CHO into the bloodstream [40]. If this definition were correct, measurements shown schematically in Figure 2.3 would be expected. True empirical measurements, Figure 2.2, contradict Figure 2.3. A new definition of GI is proposed, namely that GI provides the 'energy conversion potential' of carbohydrates [42].

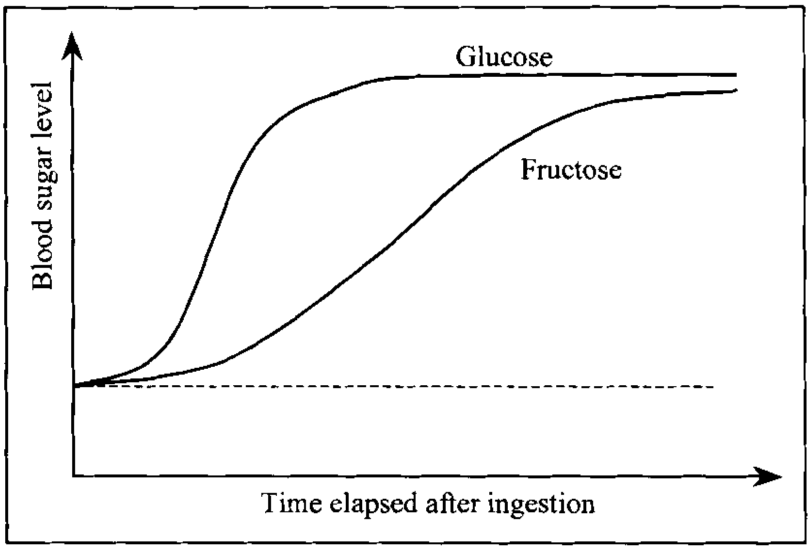

Figure 2.3 – Schematic representation of expected blood glucose response if the correct definition of GI is 'rate of digestion': Type 1 diabetic ingesting the same mass of CHO through glucose and fructose

GI expressed as a percentage (%) can now be used to find the converted CHO energy potential (E_{CHO}, measured in kCal) for a mass (m_{CHO}, measured in g) that is available to the body. Since there are approximately 4 kCal of energy in 1 g of pure glucose, E_{CHO} can be approximated with Equation (2.3a) [46].

$$E_{CHO} = 4\frac{GI}{100}m_{CHO} = \frac{GI.m_{CHO}}{25} \tag{2.3a}$$

If Equation (2.3a) is divided by m_{CHO} throughout, Equation (2.3b) is found.

$$\frac{E_{CHO}}{m_{CHO}} = \frac{GI}{25} \tag{2.3b}$$

Equation (2.3b) can be used to calculate approximate values for typical energy contents available to the body from ingested carbohydrates. In Table 2.1 a few examples of typical

GI values and their corresponding energy contents (E_{CHO}) per mass (m_{CHO}) values are shown.

Food	**GI (%)**	$\frac{E_{CHO}}{m_{CHO}}$ **(kCal/g)**
Glucose	100	4
Fructose	23	1
Apple	38	1.5
Table sugar	65	2.6
White bread	75	3
Wholewheat bread	65	2.6

Table 2.1 – Typical values for E_{CHO}/m_{CHO} *in accordance to corresponding GI values*

From the list it is clear that while on a weight loss diet, it is better for weight losers to eat less refined carbohydrates, for example, wholewheat bread than it is to eat more refined carbohydrates like white bread. This way effectively less energy is absorbed from the same amount of ingested carbohydrates [42].

The amount of energy that an individual will be able to convert also has to account for that individual's digestion and absorption ability. It is therefore not only a property of the food, but also a property of the individual consuming the food that is important.

The value of Equation (2.3b) is that, for the same individual, it is now possible to compare different foods and know which has more available energy and which has less [42].

2.3 USING ETS FOR ENERGY MEASUREMENTS

The assumption is made that fat and protein are not directly converted into blood sugar during digestion since only the carbohydrates in a meal have a significant effect on blood sugar levels. [39],[45]. This assumption holds true to a certain extent since fat and protein digestion occurs significantly slower than that of CHO.

Since different carbohydrates require different amounts of energy to digest, a 'conversion potential' is to be considered. With this all the losses during digestion, including energy needed for digestion, incomplete digestion, etc. are accounted for. In the previous section it was shown that GI provides a good approximation of this conversion potential [42].

GI is a property of the food that is considered and is not dependent on the specific person who digests the CHO. The conversion potential for CHO can be measured as discussed in Section 2.2. Many factors influence GI including mixed meal effects such as the contents of dietary fibre, fat and protein in the meal [40].

For the derivation of the ets concept, the amount of available blood sugar energy contained in a meal is considered. According to the above assumption, only CHO in a meal can provide blood sugar energy. The energy is then equal to the total amount of energy of the CHO contained in the meal and therefore also a function of the amount of CHO contained in the meal (m_{CHO}) [42].

When measured in a laboratory with processes such as bomb calorimeters, carbohydrates are found to release a certain maximum amount of energy per mass [36]. This absolute amount of available energy is denoted as k_{CHO}. The total amount of available blood sugar energy from any meal (E_{CHO}) is then the total energy ($m_{CHO}\, k_{CHO}$) multiplied with the conversion potential (GI_{CHO}). This product is shown in equation (2.4).

$$E_{CHO} = GI_{CHO} m_{CHO} k_{CHO} \tag{2.4}$$

Next the amount of energy from CHO in a meal is related to the equivalent teaspoons sugar (ets). One ets, one teaspoonful of cane sugar, contains 5g of carbohydrates. The total amount of available energy from one ets is $5k_{CHO}$ kCal. Since the GI of sugar is 65, it follows from equation (2.4) that the energy that can be extracted from one teaspoon of cane sugar is:

$$E_{teaspoon\ \ sugar} = GI_{sugar} m_{teaspoon\ \ sugar} k_{CHO} = (65)(5) k_{CHO} = 325 k_{CHO}. \tag{2.5}$$

Equivalent teaspoons sugar, or ets, is now defined as the fractional amount of blood sugar energy that can be extracted from any foodstuff, in relation to one teaspoonful of cane sugar, expressed in ets. The equation for calculating the ets of any meal is [42]:

$$ets = \frac{E_{CHO}}{E_{teaspoon\ \ sugar}} = \frac{GI_{CHO} m_{CHO} k_{CHO}}{325 k_{CHO}} = \frac{GI_{CHO} m_{CHO}}{325}. \tag{2.6}$$

Equation (2.6) can now be used to calculate the ets value for any food with a known GI value according to the portion size.

2.4 DERIVATION OF THE LINK BETWEEN INSULIN RESPONSE AND ETS

The following procedure is presented for the derivation of the equations necessary to calculate insulin response due to ingested carbohydrates. It follows from the derivation of the ets concept performed in Section 2.3.

The first important assumption is that only carbohydrates (CHO) in a meal are directly converted into blood sugar during digestion [45]. (The validity of this assumption was explained earlier.) The 'conversion potential' of CHO, approximated by GI, estimates the amount of energy that is converted into blood sugar by a typical person. All losses, including energy needed for digestion, incomplete digestion, etc. are accounted for in GI_{CHO}. This value can be measured (as discussed in Section 2.3) and is a property of the meal. It depends on many factors including the content of dietary fibre, fat and protein in the meal [40].

Energy from CHO that can be utilised by a person (E_{CHO}) in the form of blood sugar is then a function of the mass of CHO in the meal (m_{CHO}), the full energy content per mass of the CHO (k_{CHO}) measured outside the body by means of a bomb calorimeter, and GI_{CHO} of the meal which accounts for how efficiently the energy can be extracted inside the body.

Note that historically it was incorrectly assumed in diet planning that the energy content (k_{CHO}) of CHO measured outside the body by a different process (bomb calorimeter) was fully utilised inside the body through another process, namely digestion and absorption. The correct equation for CHO energy in a meal which can be utilised inside the body (E_{CHO}) is therefore shown by:

$$E_{CHO} = GI_{CHO} m_{CHO} k_{CHO} . \tag{2.7}$$

The efficiency towards converting the effective CHO from a meal (Equation (2.7)) into blood sugar varies between different people [37]. A personalised CHO efficiency can be represented by the variable f_{CHO}. (It is important to note that f_{CHO} is a function of a specific person while GI_{CHO} is a function of a meal.) The total energy absorbed in the blood for a specific person is then given by:

$$E_{Absorb} = f_{CHO} E_{CHO} = f_{CHO} GI_{CHO} m_{CHO} k_{CHO} . \tag{2.8}$$

Since E_{Absorb} is the CHO energy converted into blood sugar for a specific person, E_{Absorb} can also be found by means of blood sugar measurements for that specific person. First the response curve for blood sugar concentration ($\int BS(t)dt$) above basal level from time of consumption back to basal level has to be integrated. The time elapsed is described by Δt. The elapsed time is specific to a person's blood sugar response and is inter alia dependent on a person's insulin secretion rate and sensitivity.

The integral divided by Δt then describes the average concentration of blood sugar. The concentration has to be multiplied by the total volume of blood of the person (V_{Blood}) to find the total amount of glucose (or energy) in the blood. Finally, E_{Absorb} is then found by multiplying with k_{CHO}, the maximum energy value of CHO.

$$E_{Absorb} = \frac{\int_{t=ingestion}^{t=basal} BS(t)dt}{\Delta t} V_{Blood} . k_{CHO} \tag{2.9}$$

If Equation (2.9) is substituted back into Equation (2.8), Equation (2.10) is the result.

$$\frac{\int_{t=ingestion}^{t=basal} BS(t)dt}{\Delta t} = \frac{f_{CHO} GI_{CHO} m_{CHO} k_{CHO}}{V_{Blood} k_{CHO}} \tag{2.10}$$

Studies have shown that for a typical balanced meal containing CHO there is a direct relationship between blood sugar response ($\int BS(t)dt$) and the insulin response ($\int BI(t)dt$) [47]. Although the best fit to this relationship is not linear, a linear relationship with an R^2-value of 0.963 was found through measurements by Lee and Wolever using meals consisting of mostly CHO [48]. This is deemed acceptable, especially if equations have to be made practical for everyday use. Equation (2.11) shows this assumed linear relationship.

$$\int_{t=ingestion}^{t=basal} BI(t)dt = f_{IBS} \int_{t=ingestion}^{t=basal} BS(t)dt \tag{2.11}$$

The insulin / blood sugar relationship varies from one person to the next and this person specific characteristic can be described with the blood insulin factor, f_{IBS}. ("IBS" in f_{IBS} is an abbreviation for 'Insulin / Blood Sugar' relationship.)

If Equation (2.11) is substituted into Equation (2.10) the result is Equation (2.12), which describes the person's specific insulin response to ingested food. (The k_{CHO} values are cancelled and therefore not present in Equation (2.10).)

$$\frac{\int_{t=ingestion}^{t=basal} BI(t)dt}{\Delta t} = \frac{f_{IBS} f_{CHO} GI_{CHO} m_{CHO}}{V_{Blood}} \tag{2.12}$$

However, due to the complexity of Equation (2.12), it cannot easily be used for everyday use. The following procedure is performed in order to simplify it. Instead of using m_{CHO} and GI_{CHO} in Equation (2.12) for the meals, it is proposed that effective CHO in foods and meals can be expressed in terms of equivalent teaspoons sugar (ets).

In Section 2.4 the ets concept was derived from first order energy principles. It was shown that the GI value of a meal and the mass of the carbohydrates present in the meal can be expressed in terms of ets to quantify the total amount of energy available from ingested carbohydrates. The equation for calculating ets (Equation (2.13)) is repeated here:

$$ets = \frac{GI_{CHO} m_{CHO}}{325} \tag{2.13}$$

Interestingly, it can be shown that GI_{CHO} can be substituted with the insulin index (II_{CHO}) to arrive at a more accurate value of ets [49]. The assumptions of linearity between insulin and blood sugar response as well as high CHO content are then not needed. It should also be noted that the ets / insulin relationship is linear for much higher ets values (approximately three time higher) than the ets / blood sugar relationship. Glycaemic index (GI) values are, however, used because they are more readily available and also easier to measure.

With the ets concept Equation (2.12) can further be simplified. If Equation (2.13) is substituted into Equation (2.12) and the term Area Under the Curve of Insulin (AUC_I) is substituted for the integral, the following equations are found.

$$\frac{\int_{t=ingestion}^{t=basal} BI(t)dt}{\Delta t} = \frac{AUC_I}{\Delta t} = \frac{f_{IBS} f_{CHO}}{V_{Blood}} GI_{CHO} m_{CHO} = \frac{f_{IBS} f_{CHO}}{V_{Blood}} 325ets$$

(2.14a)

$$\therefore \frac{AUC_I}{\Delta t} = \frac{325 f_{IBS} f_{CHO}}{V_{Blood}} ets$$

(2.14b)

Equation (2.14b) can be simplified even further by defining a new person specific factor called f_{AUCI}. The factor f_{AUCI} accounts for all the person specific factors f_{CHO}, f_{IBS}, V_{Blood} and Δt in Equation (2.14b). (The notation, $AUCI$, in f_{AUCI} is an abbreviation for 'Area Under the Curve of Insulin' response.)

Among others, the factor, f_{AUCI}, of a person is a function of CHO metabolic efficiency, size, insulin resistance (which depends on fitness), body mass index (BMI), age, etc. For the sake of completeness the equation for f_{AUCI} is given in Equation (2.15) below. Measuring the individual variable is, however, difficult, so it is easier to measure the whole f_{AUCI} by simply using Equation (2.16).

$$f_{AUCI} = \frac{325 f_{IBS} f_{CHO} \Delta t}{V_{Blood}}$$

(2.15)

Substituting Equations (2.15) into (2.14b) yields the relationship between measured insulin response (AUC_I) and ingested food represented by ets. This is shown in Equation (2.16).

$$AUC_I = f_{AUCI} ets \tag{2.16}$$

In Equation (2.16) AUC_I is the integrated insulin response, f_{AUCI} is a measurable function of the individual person and ets is a measurable function of the meal. Values for ets can be found in published sources for most foods or it can be calculated by using Equation (2.13).

2.5 DERIVATION OF THE LINK BETWEEN EXERCISE AND ETS

A simplified version of the human energy system is considered. In this simplified system, when exercising, the total amount of energy expended by the body ($E_{Expended}$) is obtained from two sources, namely from the body's energy stores and from food ingested during the endurance event [37],[50],[51].

Furthermore, because all people are different physiologically, each person has a specific extraction factor (f_{Ingest}) for extracting energy ($E_{Ingested}$) from ingested food as well as a specific retrieval efficiency (f_{Store}) for retrieving energy (E_{Stored}) from stores in the body. This energy balance is shown by Equation (2.17).

$$E_{Expended} = f_{Ingest} E_{Ingested} + f_{Store} E_{Stored} \tag{2.17}$$

The aim of this derivation is to prevent low levels of blood glucose energy, because these lows can lead to hypoglycaemia. Therefore, when Equation (2.17) is examined only the energy related to blood sugar control is considered.

In the process of blood glucose control only the liver controls the raising of blood sugar levels through glycogen release [50],[52]. Studies have shown that between 15% and 25% of the energy expended during exercise events ($E_{Expended}$) is replenished from the liver stores in the form of blood sugar [51],[53]. For the sake of simplifying the problem an average factor of 20% is assumed.

In order for Equation (2.17) to describe only the energy that is available in the form of blood sugar (BS), the notation $|_{BS}$ is used. This is shown in Equation (2.18). This equation describes the portion of the exercise energy that affects blood sugar levels as well as the sources of this energy.

$$0.2E_{Expended} = f_{Ingest}E_{Ingested}\Big|_{BS} + f_{Store}E_{Stored}\Big|_{BS} \tag{2.18}$$

(In order to simplify the equations that follow, the notation "$|_{BS}$" throughout the rest of this section will not be shown, although it will implicitly be implied.)

For a better understanding of Equation (2.18), $E_{Ingested}$ first needs to be expanded. Of the food ingested during the endurance event only the carbohydrates (CHO) have a significant and immediate effect on blood sugar concentrations [45]. The CHO extraction factor, f_{CHO}, is defined to describe the athlete's ability to convert CHO into blood sugar energy. On the other hand $f_{PROTEIN}$ and f_{FAT} are defined as similar factors for protein and fat respectively.

Conversion of ingested fat and protein into blood sugar is too slow to aid in blood sugar control during the endurance exercise [50]. These two terms are therefore negligible and can be taken out of the equation as shown in Equation (2.19). The total amount of energy available for blood glucose from the ingested food is therefore given by Equation (2.19).

$$f_{Ingest}E_{Ingested} = f_{CHO}E_{CHO} + \cancel{f_{PROTEIN}E_{PROTEIN} + f_{FAT}E_{FAT}} \tag{2.19}$$

The second part of Equation (2.18), namely E_{Stored}, can now also be expanded. Of the three major energy stores in the body (fat, muscles and liver), only the liver store influences blood sugar concentrations during exercise [50]. (The energy provided by the muscles and fat stores are not converted into blood glucose for the purpose of blood glucose control.) The muscle and fat stores are therefore not considered.

The retrieval factor, f_{Liver}, describes the athlete's ability to convert stored energy in the liver into expendable exercise energy within a certain time frame. (Note that, as already mentioned, the term $f_{Liver} E_{Liver}$ can vary by up to 400% between different Type 1 diabetics and can be a complicating factor in the final equations.) $f_{Muscles}$ and f_{Fat} are similar retrieval factors for muscle and fat energy stores respectively. The energy flow from the energy stores to the bloodstream in the form of blood glucose (from Equation (2.18)) can now be written as shown in Equation (2.20).

$$f_{Store} E_{Stored} = f_{Liver} E_{Liver} + \cancel{f_{Muscles} E_{Muscles} + f_{Fat} E_{Fat}} \tag{2.20}$$

Equations (2.19) and (2.20) can now be substituted back into Equation (2.18) to arrive at Equation (2.21). This equation describes the link between expended energy and the two different energy sources for blood sugar control.

$$0.2 E_{Expended} = f_{CHO} E_{CHO} + f_{Liver} E_{Liver} \tag{2.21}$$

A healthy athlete will become hypoglycaemic when the energy store in the liver is depleted [50]. One way to prevent this depletion from occurring is by preventing the outflow of stored energy from the liver (E_{Liver}) completely through ingestion of just enough CHO (E_{CHO}) [51]. If the term $f_{CHO} E_{CHO}$ equals $0.2 E_{Expended}$, the term $f_{Liver} E_{Liver}$ can be taken out of Equation (2.21) because the flow of energy from the liver (E_{Liver}) will equal zero. This also eliminates the complication for Type 1 diabetics with their large variation in liver function ($f_{Liver} E_{Liver}$). If $f_{CHO} E_{CHO}$ is correct, their liver stores will not be utilised at all.

The suggested amount of energy from CHO ingestion, which will restrict E_{Liver} from the liver stores to zero, is henceforth given by Equation (2.22).

$$0.2E_{Expended} = f_{CHO}E_{CHO} \tag{2.22}$$

where E_{CHO} is the "effective" CHO energy available from pure glucose ($GI_{CHO} = 100$). In Section 2.4 it was shown that ingesting other types of CHO (with a different GI than glucose) large errors in energy calculations might result. For instance, an error of more than 70% will be made, if the apparent CHO energy of fructose is used without accounting for its GI of only 23. (This fact was also empirically established by Noakes [50].)

To take mixed meal and GI effects into account the 'effective amount of CHO energy' ingested has to be considered. As discussed in Section 2.4, this is described by the amount of ets contained in the ingested food.

From the derivation of ets (Section 2.3), 1 ets contains 5g of sugar (m_{CHO} = 5 g), which has a GI (or GI_{CHO}) of 65. Also, there are ideally 4 kCal of energy in 1g of carbohydrate (k_{CHO} = 4 kCal). Due to the fact that GI represents the conversion potential of the energy contained in the sugar, the energy content available to the human energy system from 1 ets (E_{ets}) is therefore 13 kCal. This is shown in Equation (2.23).

$$E_{ets} = GI_{CHO}.m_{CHO}k_{CHO} = (65\%)(5)(4) = 13 \text{ kCal} \tag{2.23}$$

Now the equivalence between E_{CHO} and ets can be expressed in terms of available energy, measured in kCal. This is represented by Equation (2.24).

$$E_{CHO} \text{ (kCal)} = 13ets \text{ (kCal)} \tag{2.24}$$

If Equation (2.24) is substituted into Equation (2.22) the following equation is found.

$$E_{Expended} = \frac{f_{CHO}13}{0.2}ets = 65 f_{CHO}ets \tag{2.25}$$

The "65" and "f_{CHO}" in Equation (2.25) can then be incorporated into one conversion factor called $f_{Expended}$ as shown by Equation (2.26).

$$f_{Expended} = 65 f_{CHO} \tag{2.26}$$

Preliminary unpublished measurements show that typical values of f_{CHO} are between 0.8 and 0.9. As a first approximation, an easy-to-use value of 55 can therefore be assumed for $f_{Expended}$.

If Equation (2.26) is substituted into Equation (2.25), the amount of CHO (measured in ets) that should be ingested during exercise is found. This amount of ingested CHO will restrict blood sugar energy flow from the liver to zero for a person with an energy expended factor of $f_{Expended}$. It is presented in Equation (2.27).

$$E_{Expended} = f_{Expended}ets \tag{2.27}$$

$E_{Expended}$ in Equation (2.27) is the total amount of energy expended during the endurance event and it is measured in kCal. It can be measured for any specific person participating in any specific event or an approximated value can be found from published exercise tables. (Importantly, these tables are developed for the 'average' athlete and do not account for the event fitness level of the specific person performing the exercise.) Furthermore, $f_{Expended}$ for the specific person can also be measured.

2.6 IMPLICATIONS OF THE NEW QUANTIFICATION

The new quantification method, ets, offers a practical viable alternative to the norm. The ets concept is based on scientific reasoning taking the complete human energy requirement into consideration. Using the ets concept a comprehensive healthy diet can be constructed for any person, for sufferers of obesity, diabetes and healthy individuals. The amount of energy needed, insulin requirements and energy expended through exercise can all be taken into account by using the ets concept.

CHAPTER 3

DIETARY PROPERTIES

3.1 INTRODUCTION

A number of different eating plans or diets are available to assist people to find the balance appropriate to their lifestyles. Not only people suffering from diabetes and obesity should be concerned with what they eat, a healthy eating plan has numerous benefits for everyone.

A diet that may be considered to be a diabetic diet is also a good diet for the completely healthy person. The aim of a healthy eating plan is to control the level of sugar in the blood by limiting the amount of carbohydrates consumed. These type of diets are therefore also beneficial to healthy people seeing that such a diet will prevent hyperinsulumneu and lower risk of developing insulin resistance.

3.2 DIETARY CONCEPTS

The human body gets its energy from the intake of nutritious food sources. The ingested food is broken down into its absorbable components through the process of digestion. The digested components are either used as, or converted into, energy for the body or stored for later use. All food is composed of macronutrients, micronutrients and water. Macronutrients include proteins, fats and carbohydrates. These macronutrients are the only food components that provide energy to sustain life. Micronutrients are vitamins, minerals and trace elements. Micronutrients do not provide energy but are essential for living. They perform cellular functions, most of which involve the efficient use and disposal of macronutrients.

3.2.1 ENERGY SOURCES FOR THE HUMAN BODY

There are five main sources for the human body to perform the functions of metabolism, movement and mental functions. The five sources that can be directly burned for use as energy in the human body are glucose, fructose, keto acids, fatty acids and ketones.

Carbohydrates are converted into monosaccharide sugars glucose, fructose and galactose through the process of digestion. Glucose is directly useable as an energy source, but galactose and fructose are first converted into glucose before utilisation. In the presence of insulin glucose is converted into usable or stored energy. The storage function (process of converting glucose to glycogen) is performed in both the liver and muscle tissue.

3.2.2 ENERGY STORAGE

The human body makes extensive use of its energy storage system to maintain and regenerate itself in a fluctuating food supply and intake pattern. Almost all tissue, with the exception of nervous tissue, is employed to store excess fuel for later use. The main fuel storage facilities in the human body are the liver, muscle tissue and adipose (fat) tissue.

The liver

The liver is a large storehouse of the following substances:

- Glycogen that has been converted from glucose;
- Triglycerides that have been derived from glucose or have been absorbed from the gastro-intestinal tract;
- Amino acids, which have been absorbed from the gastro-intestinal tract.

All of these stored fuels are short-term stored and used in preference to long-term stored fuels such as the breakdown of stored fat tissue.

Muscle tissue

Muscle tissue is the largest tissue group in a healthy individual to be used as a storage facility. The following fuels are stored in the muscles:

- Glycogen, which has been converted from glucose in the blood;

- Protein, which has been produced from amino acids and is released into the blood by the liver.

- Glycogen is a short-term storage form of glucose and used relatively quickly during exercise. Protein is the muscle tissue itself, and is therefore only called upon when other fuels are in short supply. Although not strictly fuel, protein can be converted back to amino acids and used as fuel and is accordingly considered a long-term storage form of fuel.

Adipose tissue

Adipose tissue is the storage facility for primarily long-term storage of fuel in the form of triglycerides. Fat in the body provides the reserves to be called upon in the event of longer term deprivation of fuel supply to the body. Theoretically a person can survive for months without food if fat reserves are adequate.

During exercise or long-term fasting periods the fat stores are used to replenish the shorter-term storage facilities like the liver as well as provide a certain portion of energy directly for use.

3.3 HEALTHY DIETS

3.3.1 THE NOVO NORDISK PLAN

In this section the Novo Nordisk healthy eating plan is presented. This eating plan is highlighted to show the similarities and differences between conventional diet plans and the ets diet plan.

The food pyramid shown in Figure 3-1 is suggested by Novo Nordisk. The pyramid gives an indication of what types of foods to eat and the quantities thereof to eat on a daily basis.

Figure 3-1
The Novo Nordisk eating pyramid

The food plate model shown in Figure 3-2 shows how a meal should be composed. It indicates how much of certain types of food should be eaten during a single meal to obtain a healthy and balanced meal according to Novo Nordisk.

Figure 3-2
The Novo Nordisk plate model

The guide in Figure 3-2 suggests that the meal should be divided up as follows:

- 40% Potatoes/Rice/Bread/Pasta
- 40% Vegetables and fruit

- 20% Meat/Fish/Chicken

The Novo Nordisk healthy eating plan suggests some of the following guidelines to promote a healthy balanced diet.

Meals

- Three regular meals should be eaten during the day. The meals should be of the same size and evenly spaced over the course of the day. The meals should be eaten at the same time everyday. Snacks can be eaten between meals.

- Each meal should consist of low GI starch, two to three servings of vegetables and or fruit, a moderate portion of meat, fish, chicken or egg and only one added fat.

Carbohydrates

- Low GI carbohydrates are preferable. The amount of refined sugar should be limited.

Fruit and vegetables

- At least five servings of fresh fruit or vegetables should be eaten everyday.

- Fruit juice should be consumed sparingly, preferably with meals and diluted by water 2:1.

Proteins

- Moderate helpings of meat, fish, eggs and cheese.

Fats

- The intake of saturated fats (animal) should be limited. Lean cuts of meat are preferable.

- The intake of fried foods should be limited.

General

- Special diabetic products should be limited.
- Alcohol consumption should be kept to a minimum. Wine or spirits is preferable over beer and sweet drinks. Alcohol should only be consumed with food.
- Use salt sparingly, rather replace with herbs and spices.

3.3.2 ETS COUNTING DIET

The aim of the ets diet is to minimize insulin levels and in doing, to also limit the intake of calories. By minimizing the insulin levels, the body's fat storage capability is also reduced [1]. The ets diet is easily applied and remembered because during the development of the diet particular attention was paid to the common Western lifestyle [1].

The typical Western diet is referred to as the 1-2-3 diet and is split up as 50% carbohydrates, 33% fat and 17% protein. This is similar to the Novo Nordisk diabetic diet discussed in section 3.1.1. The figures are only approximate values for a typical diet.

The ets diet controls the insulin levels and counts calories without any additional effort [1]. This ensures that the ets diet is a healthy diet for diabetics and an excellent diet for people who want to lose weight.

The ets diet tries to minimize the effort required by dieters in following the diet. The values that represent the ets in food are typically small, easy to remember and easy to add together. The portion sizes of food consumed is also classified into everyday 'generic' amounts, for example, teaspoon, cup and scoop rather than complicated metrical units. The ets diet is thus an easy-to-use everyday diet.

Unlike the Novo Nordisk diet presented in section 3.2.1, the ets diet is not a rigid diet which specifies what types of food may and may not be consumed. The diet may be customized according the personal needs of the person taking the diet.

There are nine determining factors to the ets diet:

1 Gender

- A man can consume more ets per day than a woman.

2 Height

- Tall persons are allowed more ets per day, as their energy requirement is higher.

3 Ideal weight

- The ideal weight is considered as the persons' healthy weight and thus the target weight to obtain.

4 Current weight

- The current weight is the starting point of the weight loss program.

5 Weight to lose

- The weight to lose is the difference between the current weight and the ideal weight.

6 ets allowed

- The ets allowed is calculated to realize a daily energy allowance to loose the necessary weight to go from the current weight to the ideal weight.

7 Exercise

- Exercise allows you to add more ets points per day depending on the intensity of the exercise.

8 Stress reducing effort

- Reducing stress will also have a beneficial effect. An extra ets point may be added if stress is reduced.

9 Total ets per day

- The total ets per day is calculated when taking into consideration factors 6 to 8.

The ets diet now requires some effort from the person following the diet. The person must be sure to maintain an accurate daily record of foodstuff intake and exercise performed. The ets value of each food item consumed must be subtracted from the total allowable daily ets. If there is zero ets remaining, the person has reached their recommended ets allowance for the day and should not go over their limit. The ets value of exercise performed may be added to the total recommended daily allowance (RDA) ets. This means more food may be consumed, or for people who want to lose weight faster, the exercise will help to burn off some additional energy.

3.4 INSULIN REQUIREMENTS

As mentioned previously short-acting insulin is required to lower intermittent and irregular elevations in blood glucose concentration. These elevations may occur due to a number of disturbances of which carbohydrate ingestion in the most common.

A diet consisting of a reduced amount of ets will result in less insulin secreted into the bloodstream. The reduction in insulin secreted will result in the person becoming less insulin resistant and as such reduce the risk of developing type 2 diabetes.

In this section the link between the short-acting insulin requirement and ets is derived.

3.4.1 SHORT-ACTING INSULIN REQUIREMENT

In Section 2.4 the insulin response of a healthy person to ingested CHO was discussed. It was shown that there is a direct relationship between the integral insulin response (AUC_I) and the amount of ets consumed. The relationship was described by Equation (2.16) and for the sake of clarity is repeated here.

$$AUC_I = f_{AUCI} ets \tag{2.16}$$

If AUC_I is divided by the total time of the response curve (total time it takes from time of ingestion to the time basal level is reached), the quotient represents the total amount of insulin secrete for storage of the extra blood sugar. It can therefore be deduced that there is a direct linear relationship between the integral insulin response (AUC_I) and the total amount of insulin secreted. This relationship is shown in Equation (3.1)

$$AUC_I \propto I_{Secreted} \tag{3.1}$$

A new variable can be defined to equate the linear relationship in Equation (3.1). The variable, f_I, is then a constant multiplied with f_{AUCI} found in Equation (2.16). If f_I and Equation (3.1) is substituted into Equation (2.16), Equation (3.2a) is the result.

$$I_{Secreted} = f_I ets \tag{3.2a}$$

This implies that there is a direct linear correlation between the amount of insulin a healthy person secretes and the amount of ets the person ingests. However, the magnitude of f_I, which describes this relationship, is still unknown. If Equation (3.2a) is rewritten to make f_I the object of the equation (Equation (3.2b)), it can be seen that f_I describes a value that is equivalent to insulin sensitivity.

$$f_I = \frac{I_{Secreted}}{ets} \tag{3.2b}$$

It is very difficult to measure the exact amount of insulin a healthy person secretes ($I_{Secreted}$). But the aim of the insulin injections of the Type 1 diabetics is to mimic the insulin response of healthy people [36],[55]. It can therefore be assumed that a diabetic person has to inject the same amount of insulin that a healthy person secretes. This solves the problem of not being able to measure the insulin secretion. The insulin injected by a Type 1 diabetic can be measured very accurately.

However, it is still unknown exactly how much insulin should be injected to regulate a certain amount of ingested ets. If this amount had been known, the values for $I_{Secreted}$ and ets could simply have been substituted into Equation (3.2b) to determine the insulin sensitivity (f_I). Since this is not the case, the following procedure for determining f_I is proposed:

For blood sugar control diabetics try to mimic healthy people's insulin secretion [36],[55]. The assumption is therefore made that correct blood sugar control for a diabetic would result if the diabetic injected the same amount of insulin ($I_{Injected}$) that a healthy person with an equal f_I and an equal ets consumption secreted ($I_{Secreted}$). Then $I_{Secreted}$ is equal to $I_{Injected}$ if the blood sugar levels before the meal and after the meal are equal.

Now ΔBS_{Rise} can be defined as the absolute rise in blood sugar concentration due to a meal (from time of ingestion to maximum concentration). Also, ΔBS_{Fall} can be defined as the total reduction in blood sugar concentration due to the injected insulin (from maximum blood sugar level to stabilised level after the insulin is fully absorbed). The insulin injection should be taken only after the blood sugar concentration has stabilised at its maximum level. These two definitions are shown schematically in Figure 3-3.

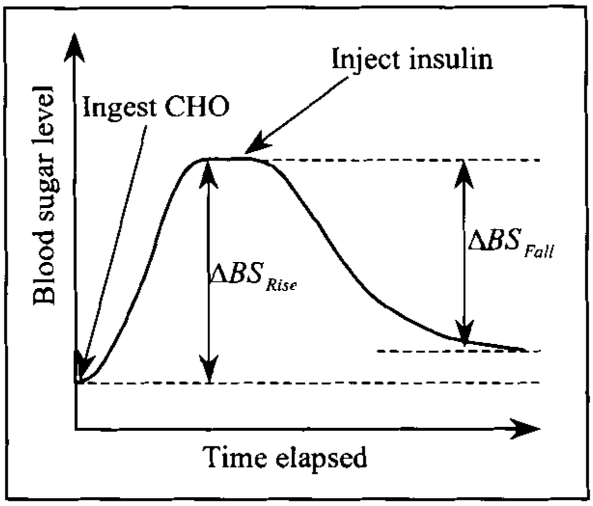

Figure 3-3 – Schematic representation of the definitions of ΔBS_{Rise} *and* ΔBS_{Fall}.

ΔBS_{Rise} and ΔBS_{Fall} would be equal if it could be measured for a healthy person. Therefore, the quotient of the two variables would be unity. Also, $I_{Secreted}$ is equal to $I_{Injected}$, so this can be substituted into Equation (3.2b) as shown in Equation (3.3).

$$f_I = \frac{I_{Secreted}}{ets}\frac{\Delta BS_{Rise}}{\Delta BS_{Fall}} = \frac{I_{Injected}}{ets}\frac{\Delta BS_{Rise}}{\Delta BS_{Fall}} \tag{3.3}$$

However, if a Type 1 diabetic administers insulin manually, and the amount ($I_{Injected}$) is not the correct amount to ensure that final blood sugar level is equal to the starting level, then ΔBS_{Rise} and ΔBS_{Fall} will differ. This is not a problem, because due to the linearity of Equation (3.3), the $\Delta BS_{Rise}/\Delta BS_{Fall}$ quotient will scale the equation linearly and keep f_I constant.

Therefore, Equation (3.3) can be used as a method of calculating f_I for a Type 1 diabetic. The procedure is shown schematically in Figure 3-3. First the patient should have a relatively constant blood sugar level, typically after fasting for a few hours. Then a meal consisting of a certain number of ets should be ingested.

A number of consecutive blood sugar measurements should be taken during approximately the next hour to determine the total rise in blood sugar due to the ingested ets. The rise in blood sugar (ΔBS_{Rise}) is then the difference between the maximum measured level and the starting level.

After the blood sugar levels have stabilised, a certain amount of short-acting insulin should be injected. Over the next two to three hours the blood sugar should again be monitored until a constant level is reached. To determine ΔBS_{Fall}, the final stabilised blood sugar level has to be subtracted from the maximum level previously measured.

All these measurement can be substituted into Equation (3.3) and f_I can subsequently be measured. Lastly, the final value of f_I can be substituted into Equation (3.2a) (together with $I_{Secreted} = I_{Injected}$) to determine the required short-acting insulin injection for any meal containing a known number of ets. The final equation is shown in Equation (3.4).

$$I_{Injected} = f_I ets \tag{3.4}$$

3.5 IMPLICATION OF A LIMITED ETS DIET

Both ets diets were tested in the clinic of Dr Pieter Ackermann who is a bariatric physician. Their success was not only measured in terms of successful fat loss, but also in terms of positive feedback from ets dieters. All dieters said that this way of eating was the best they had ever tried and that it was easy to implement and sustain.

A further discovery was that the full-blown ets diet was particularly suitable for pregnant women. It is especially safe during pregnancy, because it provides all the energy needed by a pregnant woman, but it also allows her to lose weight after pregnancy and to maintain it.

Over a period of 12 months 686 new patients were introduced to the ets concept of dieting. The usual mode of conduct was to perform a body statistic analysis during the first consultation. This determined the relationship between fatty and lean tissue.

After a predetermined interval (or when a certain goal was reached), the procedure was repeated. It was observed that mostly fat was lost while the lean muscle tissue remained. The patients lost and average of 0.564kg per week throughout the entire treatment period.

CHAPTER 4

Development of mobile phone software using ets

4.1 BACKGROUND

Dietary assistants are tools developed for the specific purpose of assisting their users in making better choices concerning the food that they consume. These tools may be used by a variety of users. The user may wish to control his/her diet to lose weight, assist diabetics with their insulin dosage or just to assist the user in maintaining a healthy diet.

A wide variety of tools are available on the market to assist people with dietary concerns. These tools range from simple paper slide rules to very complex electronic devices. These tools serve a useful purpose for the users when they are used correctly. They are however very limited in the assistance that they can provide to the user and are, in the case of the more complex electronic tools, very difficult to learn and use effectively. The user may at some point just decide not to use the device simply because it is too time consuming and troublesome to use.

A better solution for a diet assistant would be a device that is easy to use and offers a great amount of flexibility. A cellular phone based diet assistant would solve a number of the problems currently experienced with the conventional tools available. In modern times we are moving towards a single device that can be used to perform a multitude of functions. The cellular phone is an obvious choice for such a device. The cellular phone is a widely accepted tool. Even among some of the poorest segments of the population, cellular phones play an important role in daily lives.

With the so-called 'smart phones' now becoming an everyday sight, the technology has matured sufficiently for the implementation of tools such as a dietary assistant. Smart phones form sophisticated platforms that enable the developer to develop tools that were previously regarded as infeasible.

A cellular phone based dietary assistant has certain advantages above its more conventional competitors. The smart phone platform supports multiple databases, a graphical user interface, a large amount of memory for storage and sufficient processing power for complex calculations. As is the norm nowadays the smart phone also features the latest in ergonomic user interfaces, which greatly reduce the complexity of using the smart phone for various functions. The greatest advantage of the cellular phone is its ease of use and there is no need to carry the burden of an additional device to act as the diet assistant.

4.2 SYSTEM DESIGN

The system designed during this study aims to provide a viable alternative to the norm. Currently a great amount of effort and time is required to make effective use of digital dietary assistants.

The main aim of the design is to deliver an easy to use software dietary assistant. The software will allow the user to effectively manage his/her diet by accepting inputs from the user. The user will provide physical characteristics about him-/herself and will log nutritional and exercise data. The user will be able to access dietary information and determine his/her dietary status at anytime.

This section will provide a detailed description of the dietary assistant design. The design description will be given in terms of a functional design and diagrams.

4.2.1 FUNCTIONAL ANALYSIS

A description of the functional block diagram shown in Figure 4-1 is given below.

- Functional Unit 1 (FU1): The user must provide certain details (e.g. current weight, gender, age, height, activity level etc.) in order for the system to calculate the dietary advice. The information needed from the user is entered through FU1. The information is stored in the setup database that is shown as functional unit 14 (FU14).

- Functional Unit 2 (FU2): Any exercise that the user is involved in is entered through FU2. The information needed by FU2 is delivered by the exercise database, functional unit 12 (FU12), and the entry for the exercise is made to the logbook database, functional unit 11 (FU11).
- Functional Unit 3 (FU3): Food consumed by the user is entered into the system through FU3. The food database, functional unit 10 (FU10) is used to provide information about the food the user can select. The entry in made to the logbook database, functional unit 11 (FU11).
- Functional unit 4 (FU4): Favorite meals may be defined through FU4. These meals are meals made up out of food items that are repeated often. The favorites are stored in the favorites database (FU13). Entries can also be made into the logbook database FU11 from FU4.
- Functional Unit 5 (FU5): The total amount of food consumed and exercise done computed by FU5. The logbook database (FU11) provides the information that is needed by FU5 to calculate the totals.
- Functional Unit 6 (FU6): For every user there are different recommended daily allowance (RDA) values. These values are calculated by FU6 based on information obtained from the setup database, functional unit 14 (FU14).
- Functional Unit 7 (FU7): The result of FU6 is passed to FU7 where it is given as output to the user.
- Functional Unit 8 (FU8): The entire logbook is displayed to the user. All the entries made to FU11 are shown.
- Functional Unit 9 (FU9): The totals for the day are given to the user. Totals for food consumed and exercise done are shown.
- Functional unit 10 through functional unit 14 are the data storage units for the system. The food database FU10 stores categories of food items with their associated nutritional values. The exercise database FU12 stores different types of exercise and the amount of energy used by the exercise for a specific time unit. The favorites database FU13 stores all the information of the defined favorite meals similar to the food database F11. The logbook database FU11 stores all the information regarding food items consumed and

exercise done. The setup database FU14 stores all the user specific information and the software setup options.

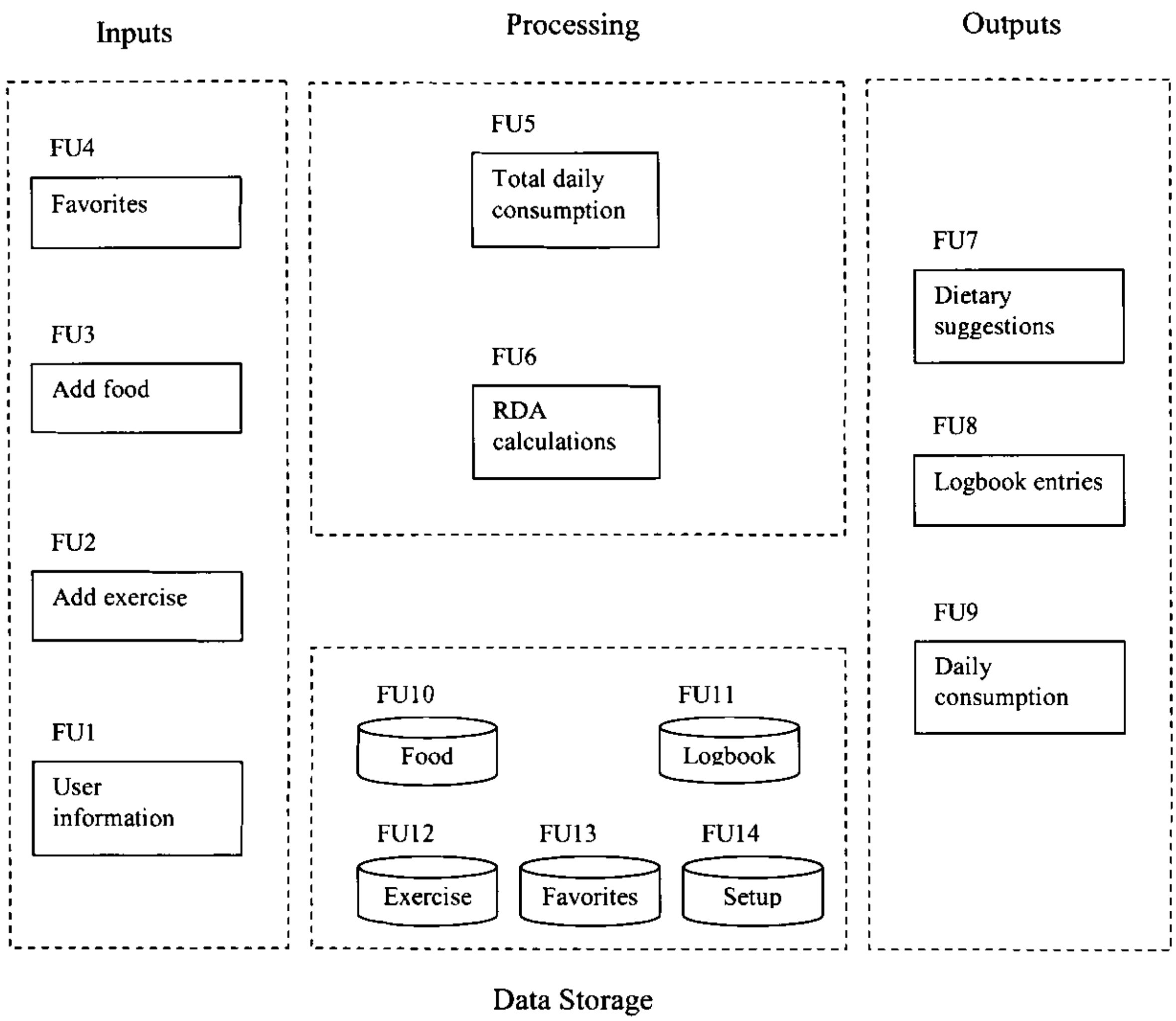

Figure 4-1

The functional block diagram

4.2.2 SYSTEM SPECIFICATION

This section specifies the system specification.

- The system must make use of the ets dietary concept to assist the user in dietary decisions.

- The system must provide the following nine options: Logbook, Food, Exercise, Totals, Favorites, Setup and Quit.
    - The system must provide a graphical user interface. The interface must allow the user to easily navigate the menus and identify all the functions of the system.
- The system must allow the user to select a food item eaten from a database of predefined items. This is to promote accuracy of the food nutritional values and also to ease the burden of entering food items on the user.
    - The system must allow the user to select the amount consumed of a certain food item by making use of an easily interpreted unit for the item.
    - The system must allow the user to search through the food database to increase the speed of adding an item to the logbook and ease the burden of searching manually through the list of food items.
    - The system must allow the user to define regular eaten meals made up from the food items available in the food database. The user should be able to give each meal a custom description. The user should also be able to delete the meals.
- The system must allow the user to add a specific type of exercise to the logbook by selecting the exercise from the exercise database.
    - The system must allow the user to change the duration of the exercise to suit the user requirements. This is to promote accuracy of the calculations made based on the exercise done by the user.
- The system must provide the user with the ability to view the daily dietary totals. This is to allow the user to understand how much nutritional value is still available for the day.
    - The dietary totals must be represented in graphical format, which allows for easy and quick interpretation of the totals.
    - The totals option must provide a pie chart to indicate to the user how the nutrition for the day consumed is divided up in terms of percentage fat, protein and carbohydrates.

- The system must allow the user to enter the user specific information through several different setup screens. This is to ensure ease of use of the setup menu and to prevent clutter in the setup menus.
  - The setup must ask for the following information: weight, height, activity level, gender, age, ets RDA, etsCal RDA, kCal RDA and KJ RDA.
  - The setup menu must calculate the RDA values for ets, etsCal, kCal and kJ. These RDA values must be given as suggestions to the user. The user must be able to adjust the values accordingly.
  - All the input values must be adjustable by moving the joystick button either up or down or left or right.
- The system must allow the user to view all the logbook entries made. This is to allow the user to verify that all the entered data into the system is correct. It also serves as a memory for the user to remember all the dietary information for the day.
  - The system must allow the user to clear the entire contents of the logbook as well as to remove only a single entry in the logbook.
- The system must provide five databases to store all the necessary information needed for the operation of the system.

4.3 SOFTWARE ARCHITECTURE

A description of the software architecture is given in this section. The architecture is illustrated using diagrams to show the flow of events. The software flow is based on events that the user generates by interfacing with the system.

The diagrams below illustrate how the software must react when the different options are exercised. There are seven options available to the user. All the options are initiated through the main menu of the software.

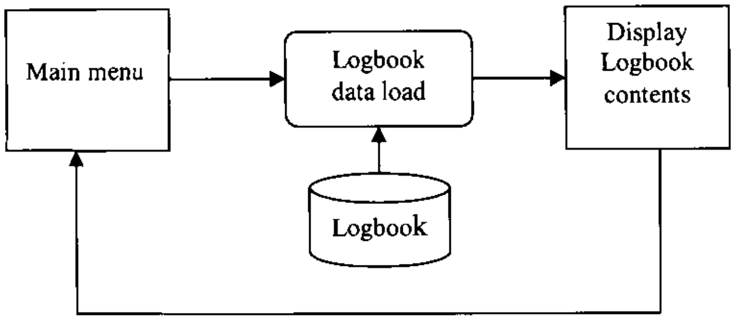

Figure 4-2

The logbook option

The logbook option is selected in the main menu by the user. The 'logbook data load' process loads all the entries for the day into main memory. The contents of the logbook are shown on the logbook display screen. The process is shown diagrammatically in Figure 4-2.

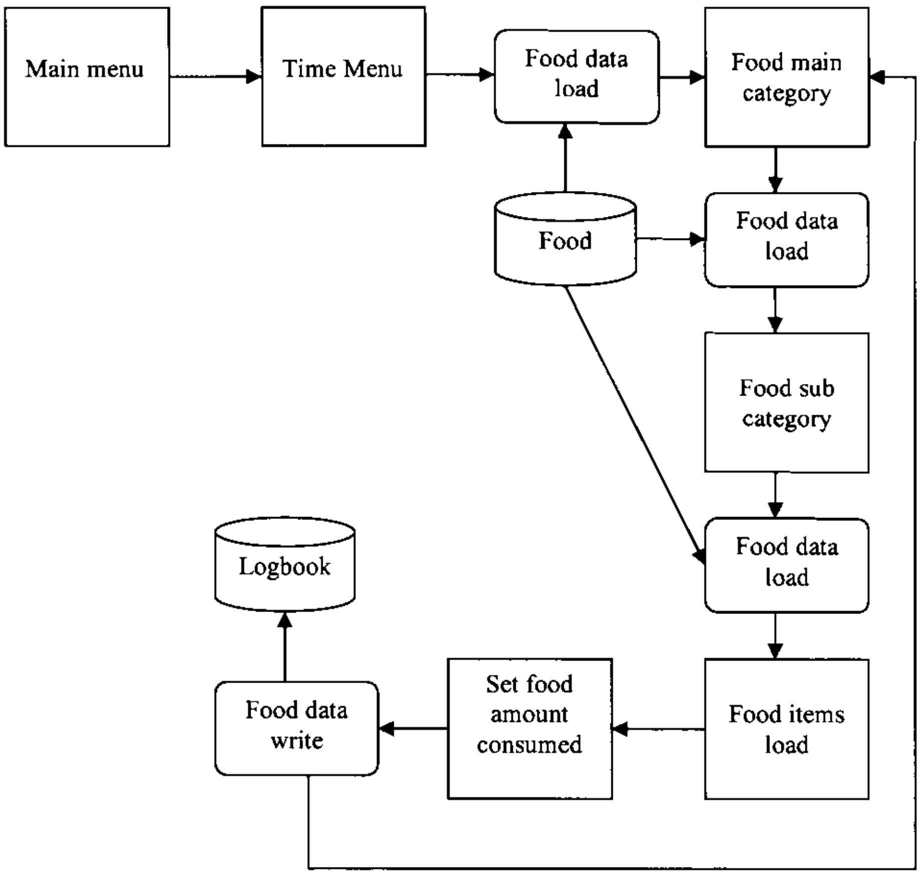

Figure 4-3

The food option

The food option is likely to be one of the most often exercised options from the main menu. The process is highlighted in Figure 4-3. The user selects the food option from the main menu. The user will be prompted for a time when the meal was consumed. The main category of the food database is loaded into primary memory and shown on the food main menu. The user makes a selection on the main food menu. The food sub categories are loaded from the food database and displayed on the food sub menu. The user selects an item from the sub category menu. The food items are loaded from the food database and displayed on the food item menu. The user selects the food item that was consumed. The user is prompted to indicate the amount of food portion consumed. The food item is written to the logbook together with all the nutritional values associated with that food item. The menu returns to the main food menu, ready for the process to start again.

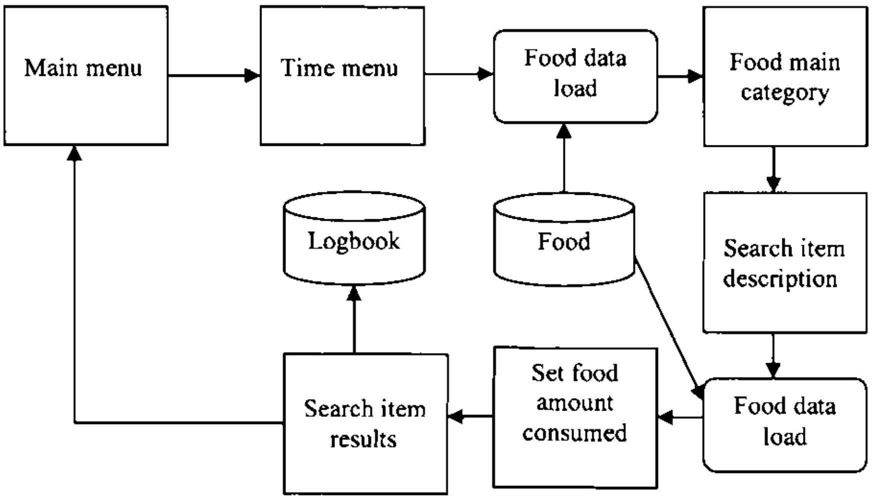

Figure 4-4

The food search option

The food search option offers the user the ability to easily search through the food database without having to resort to searching manually through the complete database. This process is illustrated in Figure 4-4. The user selects the food option from the main menu. The user is prompted for the time that the item was consumed. The main food category is loaded from the food database. The user selects the first item on the main food menu: Search for food item. The user enters a text description of the item consumed. The food database is searched for items matching the description. The results of the search are shown on the search results menu. The user selects the item from the search results menu. The user is prompted for an indication of the amount of the item consumed. The item is written to the logbook database. The main menu is presented to user again.

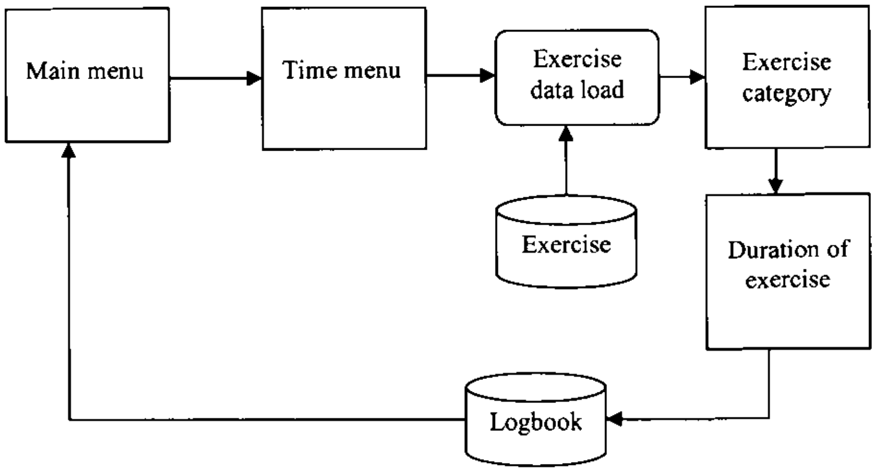

Figure 4-5

The exercise option

The process whereby exercise is entered into the logbook is shown in Figure4-5. The user selects the exercise option from the main menu. The user is prompted for a time when the exercise was done. The exercise data stored in the exercise database is loaded into main memory by the 'exercise data load' process. The exercise categories are shown on the main exercise menu. The user selects the desired exercise. The user is prompted for an indication of the duration of the exercise. The exercise is written to the logbook database. The user is returned to the main menu.

The process whereby the daily totals are calculated is shown by the diagram in Figure 4-6. The user selects the totals option from the main menu. The data needed to calculate the daily totals are loaded from the logbook and setup databases. The totals are calculated by the 'calculate totals' process. The totals are displayed to the user. The 'draw pie chart' process draws a pie chart of the nutritional content of the food entered into the logbook. The pie chart is presented to the user. The totals process returns to the main menu.

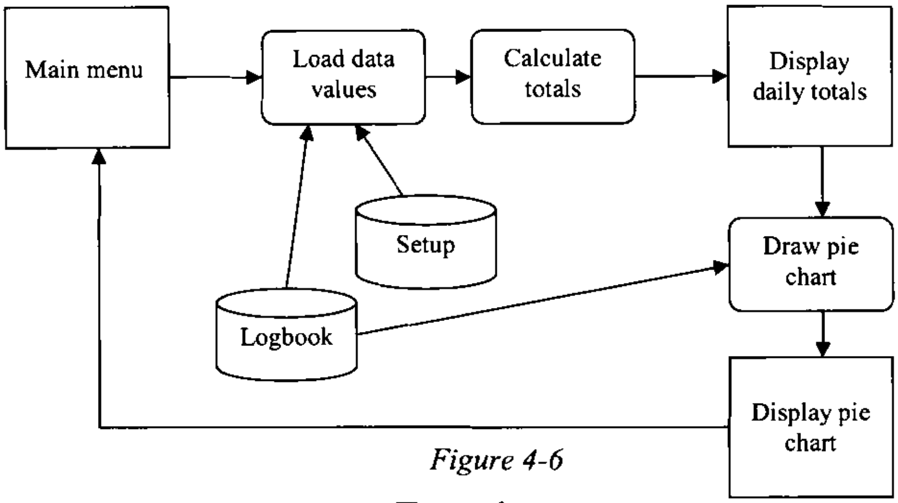

Figure 4-6

The totals option

The process whereby a predefined favorite meal is written to the logbook is shown in Figure 4-7 below. The user selects the favorites option from the main menu. The 'load favorites' process loads the favorites list from the favorites database. The list of favorites is presented to the user. The user selects the appropriate meal from the list and is presented with a breakdown of the items contained within the meal. The meal is written on the logbook database. The user is presented with a confirmation screen of the action taken. The process returns to the main menu.

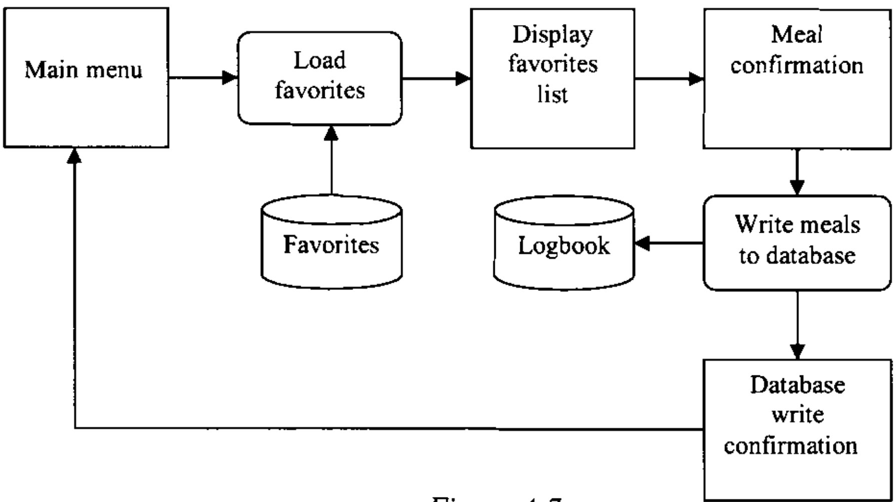

Figure 4-7

The favorites option

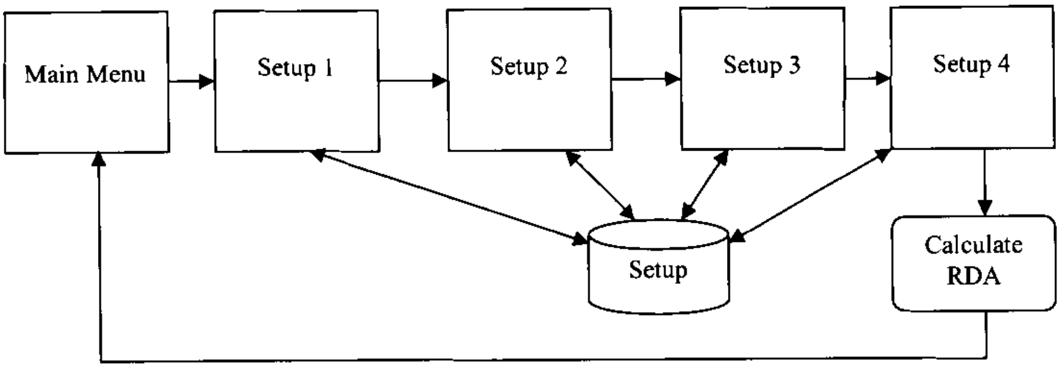

Figure 4-8

The setup option

The setup process is shown by the diagram in Figure 4-8. The user selects the setup option from the main menu. The user is presented with four consecutive setup screens. Each screen is loaded with the current values stored in the database. The user can modify the setup values according to his/her requirements. The recommended daily allowance (RDA) values are calculated by the 'calculate RDA' process. All the values are written to the setup database. The process returns to the main menu.

4.4 CALCULATIONS

4.4.1 RECOMMENDED DAILY ALLOWANCE ETS CALCULATION

To calculate a person's recommended daily allowance (RDA) the following method was implemented.

Based on the research done by Mathews [56], the equations for calculating the RDA ets were derived. The equations are derived from the tables shown in Appendix A. Curve fitting methods was used to fit a single quadratic function to all the data points in the different categories. There are eight different categories divided into a pair or four sub categories each. The categories are divided by gender and the person's activity level. The categories are as follows:

- Male
  - o High activity level
  - o Normal activity level
  - o Light activity level
  - o Weight losers
- Female
  - o High activity level
  - o Normal activity level
  - o Light activity level
  - o Weight losers

The two graphs below show how each of the above categories' RDA functions are determined from the curve fitted data. The resultant functions are used to calculate the RDA value for a specific person. The function takes the height of the person as a parameter.

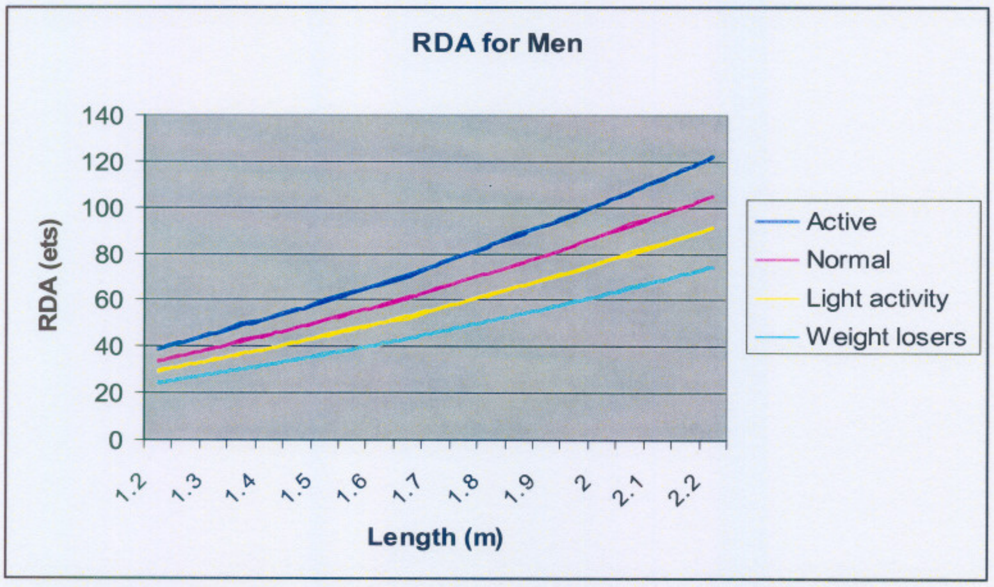

Figure 4-9

The RDA graphs for men

In all of the following equations the *h* represents the persons height in meters.

Equation (4.1) gives the RDA ets for an active male:

$$ets_{RDA} = 0.0547h^2 + 2.9327h + 36.123 \tag{4.1}$$

Equation (4.2) gives the RDA ets for a normal active male:

$$ets_{RDA} = 0.0457h^2 + 2.5581h + 30.988 \tag{4.2}$$

Equation (4.3) gives the RDA ets for a lightly active male:

$$ets_{RDA} = 0.0417h^2 + 2.1704h + 27.262 \tag{4.3}$$

Equation (4.4) gives the RDA ets for a male that wants to lose weight:

$$ets_{RDA} = 0.0327h^2 + 1.7834h + 22.314 \tag{4.4}$$

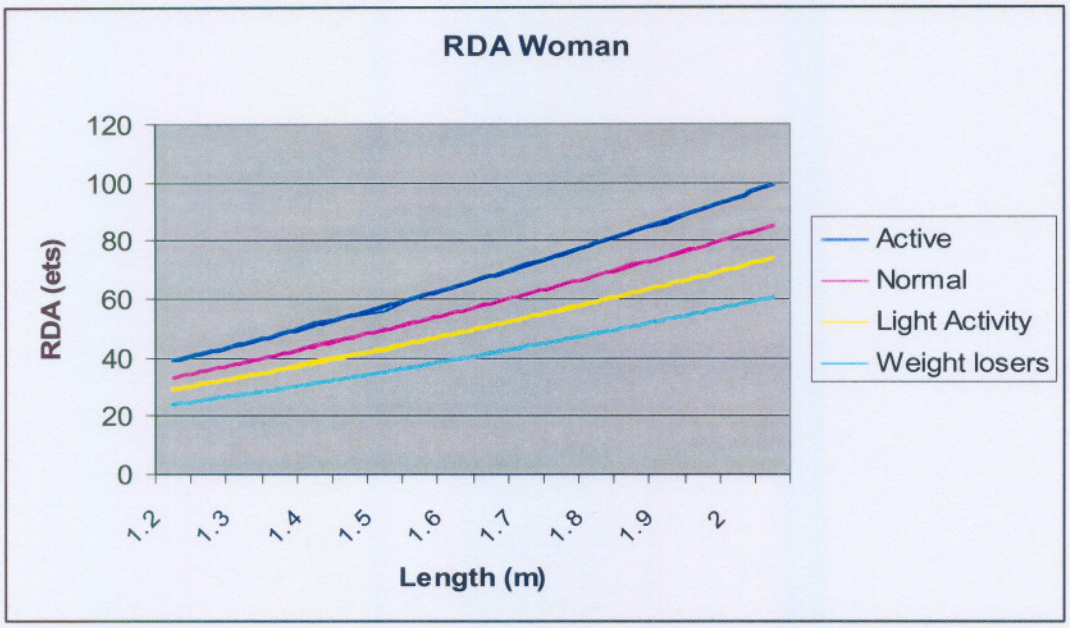

Figure 4-10

The RDA graphs for women

Equation (4.5) gives the RDA ets for an active female:

$$ets_{RDA} = 0.0419h^2 + 2.7444h + 36.135 \quad (4.5)$$

Equation (4.6) gives the RDA ets for a normal active female:

$$ets_{RDA} = 0.0314h^2 + 2.4579h + 30.748 \quad (4.6)$$

Equation (4.7) gives the RDA ets for a lightly active female:

$$ets_{RDA} = 0.0294h^2 + 2.0769h + 27.157 \quad (4.7)$$

Equation (4.8) gives the RDA ets for a female wishing to lose weight:

$$ets_{RDA} = 0.0263h^2 + 1.655h + 22.257 \quad (4.8)$$

4.4.2 THE DAILY TOTALS CALCULAION

The daily totals are given as ets, etsCal and kCal. These are the total nutritional content consumed for the day. The totals are summed from the data stored in the logbook. The user makes entries into the logbook by selecting items from the different databases. The nutritional values for these items are also stored in the respective databases.

4.5 DESIGN DISCUSSION

The dietary assistant is an application that is data and event driven. The software requires events generated by the user in order to perform its functions. This is all that is required as there are no continuing processes that need to be updated periodically. This means there is no need for complex timing or kernel management which greatly simplifies the software design. The data processing will take place on data stored in five different databases. The hardware platform used to run the application should thus be able to provide the necessary support for large data storage. The design will guide the user through the steps needed to achieve the desired outcome. The software will be a form based graphical user interface. Each logical path flow followed by the user will result in similar steps to follow. The user should thus be able to become accustomed to the logic of the software quite quickly.

The design is successful in providing the functionality required for the dietary assistant. The tools and platforms are available to implement the design successfully and efficiently. The design is simple enough to be easily implemented without any complex functions to resolve.

The implementation of the design is shown in the following chapter.

CHAPTER 5

IMPLEMENTATION OF THE SOFTWARE

5.1 INTRODUCTION

In this chapter the implementation of the cellular phone based ets dietary assistant is presented. This chapter's intent is to show the reader how the research and architectural design were brought together to realize a functional implementation.

5.2 IMPLEMENTATION

5.2.1 THE IMPLEMENTATION PLATFORM

The platform chosen to implement the dietary assistant is the cellular phone shown in the figure below.

Figure 5-1
The Nokia 6600 cellular phone

At the time of development of the dietary assistant the Nokia 6600 was released and represented the latest in cellular phone technology. The dietary assistant can also be adapted to function on any of the latest cellular telephones which makes use of the Symbian operating system.

5.2.2 THE CHOICE OF CELLULAR PHONE

The cellular phone itself has undergone rapid technological development in the last few years. Cellular phones are no longer merely devices used to make phone calls. Cellular phones are powerful devices which can be used to execute powerful applications for various tasks. This makes the choice of which cellular phone to use for an application such as the dietary assistant both difficult and easier. The difficulty is in making a suitable choice from the vast variety of phones available on the market. The choice is made easier due to the fact that these phones now have enough processing power and resources to support complex graphical user interfaces (GUI) and mathematical calculations.

For this study a number of practical limitations had to be considered when making the choice of phone.

The development tools that were already available dictated some of the decisions. The tools already available were:

- Microsoft Visual Basic 6.0
- Appforge Crossfire 5.0

These tools dictated that a cellular phone with a Series 60 platform had to be used.

At the time of development the MTN call centre confirmed the following phones that were available on the Series 60 platform:

- Nokia 6600
- Siemens SX1

- Sony Ericsson P900

Based on the information given by the MTN call centre at the time, the Nokia 6600 was selected as this phone is regularly available and is the more popular phone of the three.

5.2.3 THE CHOICE OF PROGRAMMING LANGUAGE

There were two alternatives considered for the programming language:

- Java J2ME
- Microsoft Visual Basic 6.0

The Java J2ME is a very popular open source development environment with all of the necessary development tools available at no cost. There are numerous J2ME applications available and these applications are not limited to the Series 60 platform.

Developing a GUI application in J2ME is considerably more involved than developing the same application in Microsoft Visual Basic. The J2ME applications also tend to be slower than the equivalent Microsoft Visual Basic application.

The Microsoft Visual Basic 6.0 interactive development environment was already available for use in the study. In order for a Microsoft Visual Basic 6.0 application to function on a cellular phone, a booster software package must be installed on the cellular phone. The Appforge Crossfire V 5.0 was available to the study at no extra cost.

5.3 THE APPLICATION

In this section the practical implementation of the application for the dietary assistant is described. The final results of the development effort are illustrated through the use of figures.

5.3.1 THE MAIN MENU

Figure 5-2
The main menu of the dietary assistant

Figure 5-2 shows the main menu of the ets dietary assistant. The menu is made up of a matrix of logos with descriptive wording added. The intention is to make it easy and fast for the user to locate the desired function. With a comfortable look and feel the user is more at ease and more willing to make the effort to use the assistant regularly.

5.3.2 THE LOGBOOK

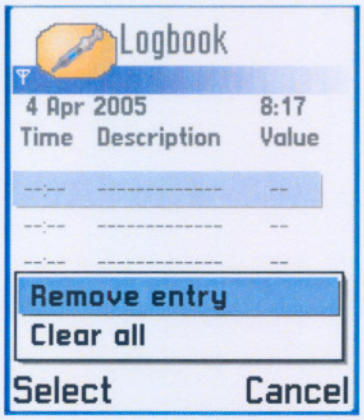

Figure 5-3
The logbook menu

The logbook menu is shown in Figure 5-3. The logbook keeps record of all the data entered into the assistant. All the meals, exercise, blood glucose levels and insulin suggestions are stored in the logbook. The logbook option allows the user to view the contents of the logbook for that specific day. The time of the entry, description and ets value of the entry are shown. Figure 5-3 also shows the submenu which has options to remove an item from the logbook or to clear the entire logbook.

5.3.3 THE FOOD MENU

Figure 5-4 below shows how the user would proceed to enter a food item into the logbook.

The user selects the food option from the main menu. The time of the meal must be entered. The user is then presented with the main category view of the types of food items available in the food database. After making a selection the user is presented with a sub category view from which another selection must be made. The final sub category contains the specific food items that the user must make a selection from. Finally the user is asked to enter the amount of the food portions consumed.

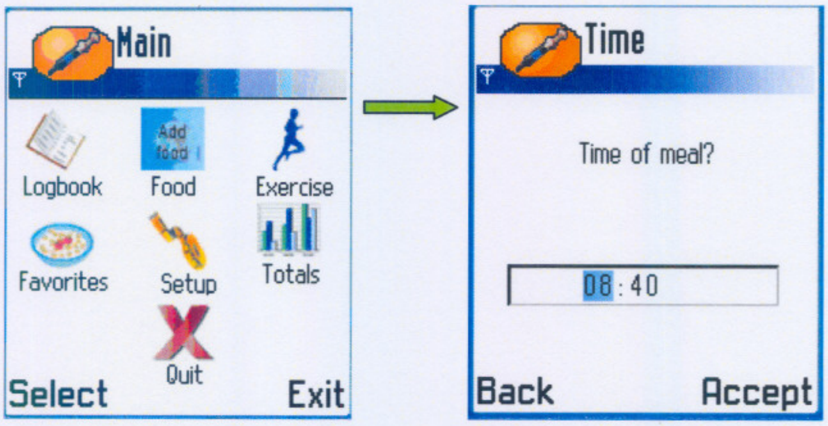

Figure 5-4
Making a food item entry into the logbook

5.3.4 THE FOOD SEARCH ENGINE

The food search engine greatly improves the user friendliness of the dietary assistant. The search engine's practical implementation is shown in Figure 5-5 below.

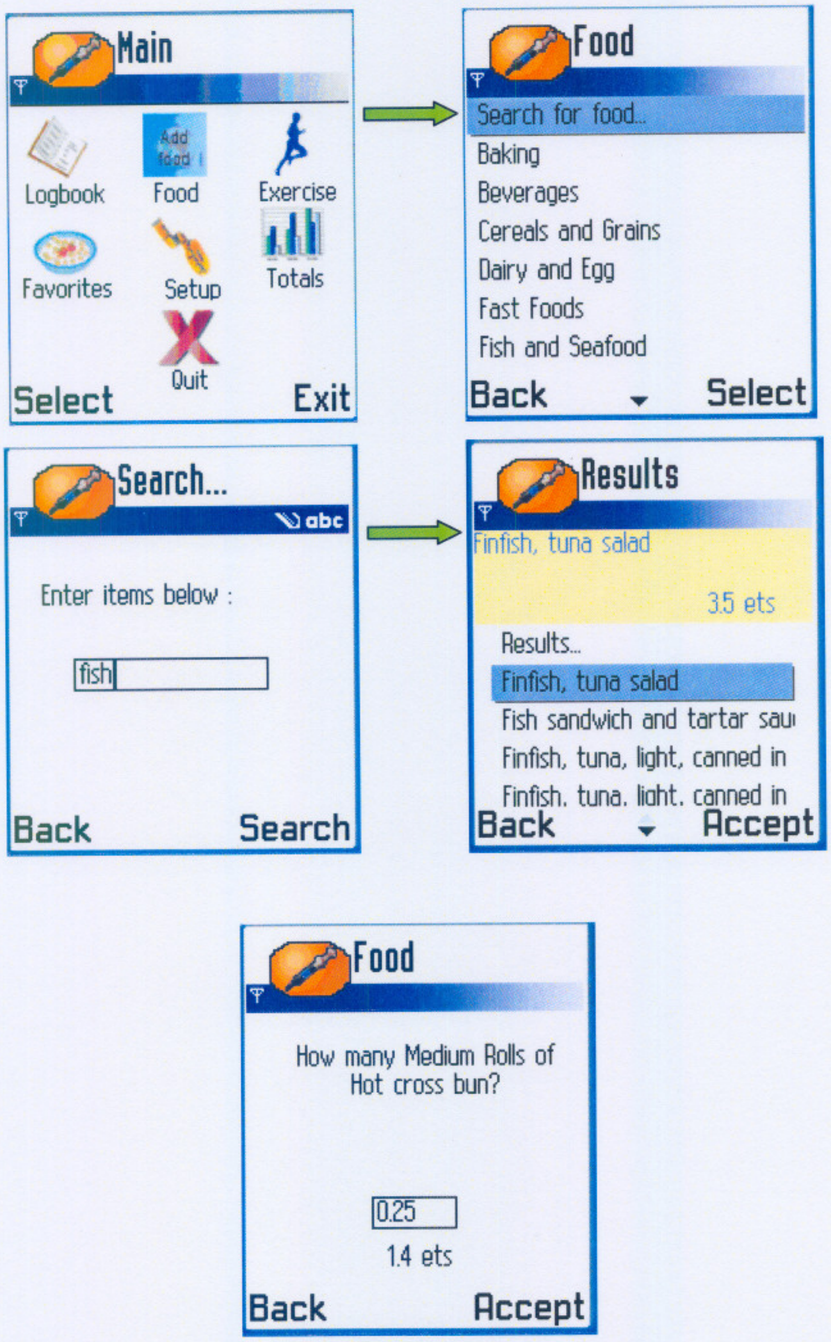

Figure 5-5
The food search engine menus

The user follows the steps outlined in Figure 5-5. The search engine allows the user to quickly search through the entire food database, based on a search string provided by the user.

5.3.5 THE EXERCISE MENU

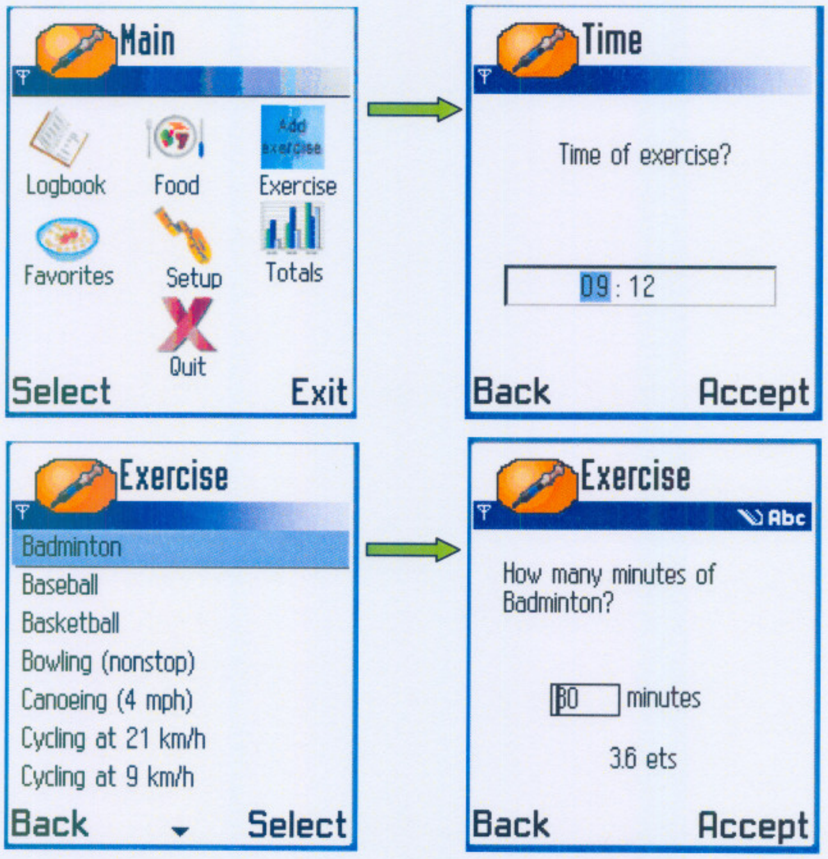

Figure 5-6

The steps to follow to add exercise

After completing an exercise routine the user must enter information regarding the exercise into the logbook. This is accomplished by selecting the exercise option from the main menu. The user is prompted for the time when the exercise was completed. The assistant contains an exercise database with various types of exercise for the user to choose from. The user makes a choice from the exercise list where after the user is prompted for the duration of the exercise. All the information supplied by the user is logged into the logbook when the accept button is pressed.

5.3.6 THE TOTALS MENU

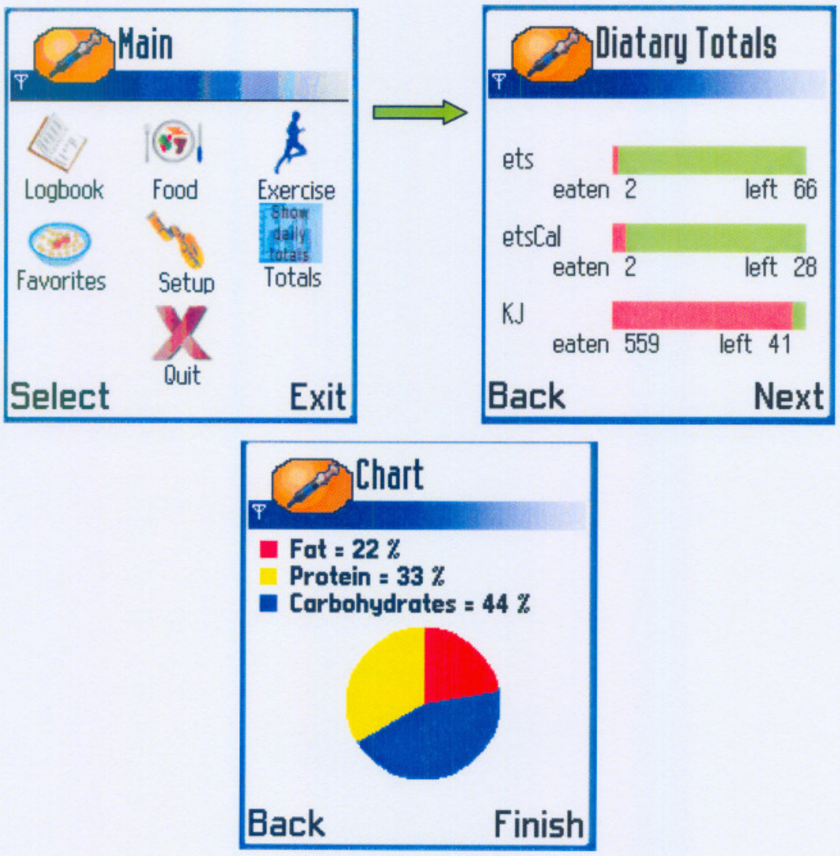

Figure 5-7

The daily totals

Figure 5-7 above shows the daily totals menus. The daily totals are accessed through the selection of the Totals options from the main menu. The dietary totals are shown in the form of three bar diagrams. The diagrams show the amount of food energy consumed for the day and how much is still available. The pie chart shows the composition of the food consumed as percentage fat, protein and carbohydrates.

5.3.7 THE FAVORITES MENU

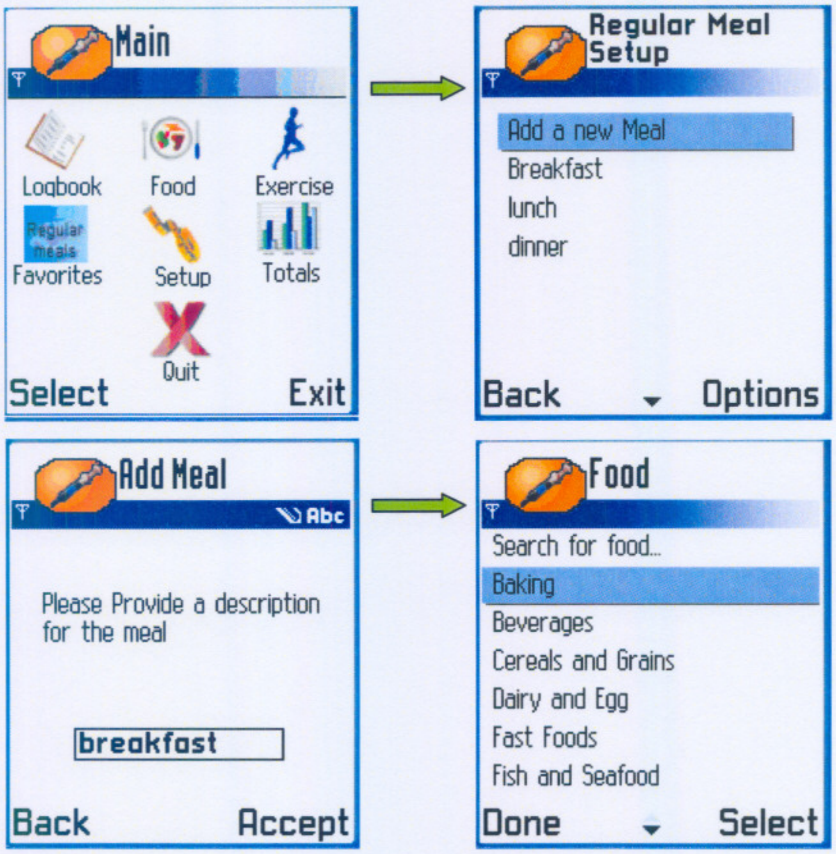

Figure 5-8

The add new meal procedure

Figure 5-8 shows how to add a new favorite meal to the favourites database. A favourite meal is a meal made up of items that are consumed regularly. The user can thus select all the items of that meal with one entry for that specific meal. This greatly reduces the input effort on the user's side.

To enter a new favourite meal the user must select the Favorites option from the main menu. In the next step the user must select the Add a new meal option. The user is prompted to give a description for the new meal. After a description is entered, the user can select all the items that make up the favorite meal. The same procedure is followed as the Add food option. When the user is done compiling the favorite meal the Done option is selected and the favorite meal is written to the favourites database.

Figure 5-9

A list of regular meals

The list of regular meals is shown in Figure 5-9. The list shows all the favourite meals in the favourite database. When a new meal is created, the final screen showed to the user is the list of favourites including the newly created meal.

In Figure 5-10 below the steps to follow to add a favourite meal as a logbook entry is shown. The favourites option is selected from the main menu. The user is presented with the list of favourite meals stored in the favourites database. The user selects the appropriate meal from the list. The items that the selected meal is composed of are shown to the user. The user is prompted for a time when the meal is consumed. After the time is entered, the meal is written to the logbook database and the user is presented with a confirmation message.

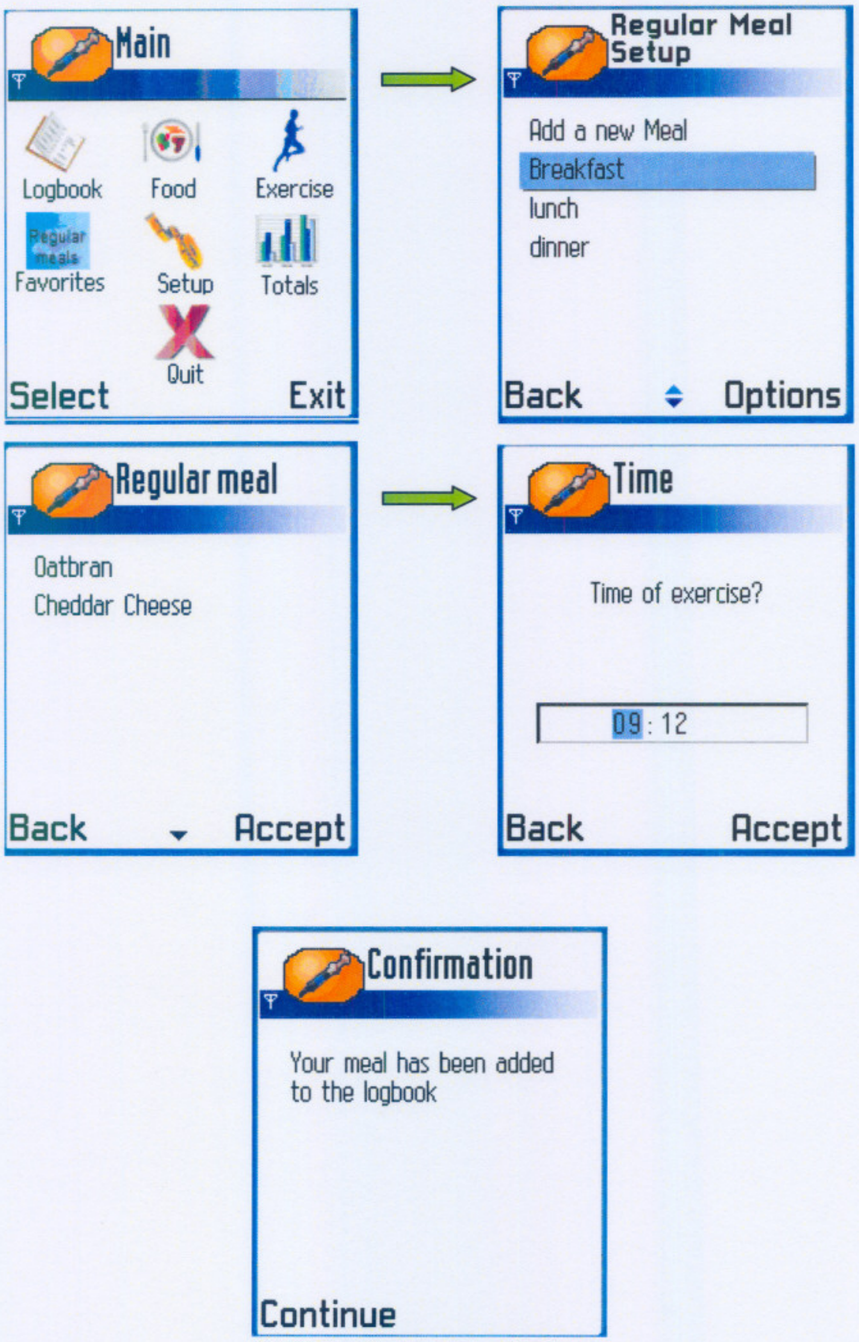

Figure 5-10

The steps to add a meal to the logbook

5.3.8 THE SETUP MENU

The final item in the main menu is the Setup option.

Figure 5-11

Setup screen 1 of 4

In Figure 5-11 above the first of the setup screen can be seen. The user's weight, height and activity level are used to compute the recommended daily allowance (RDA) values for the user's diet. The joystick is used to move between the different elements on the screen. To adjust the values for the weight and height, the navigation key is pushed to the right to increase the value and left to decrease the value.

Figure 5-12

Setup screen 2 of 4

The second setup screen is shown in Figure 5-14. This screen requires information about the user's gender. The user's gender also plays a determining role in the user's RDA. Typically a male will have a higher RDA than a female.

Figure 5-13

Setup screen 3 of 4

The third setup screen is shown in Figure 5-13. This screen requires information about the user's age. This is used during the calculation of the RDA values. The navigation is used to adjust the value; the navigation is pushed to the right to increase the value and to the left to decrease the value.

Figure 5-14

Setup screen 4 of 4

The final setup screen is shown in Figure 5-14. This screen requires information about the user's RDA. Suggested values for the user's RDA are provided in the red font next to the respective value boxes. The values may be adjusted selecting the appropriate value by using the joystick. Move the navigation key to the right or to the left to increase or decrease the values.

The Kcal or KJ values are selected by moving the cursor to the final value box on the display, pressing down on the navigation key once. The Kcal and KJ options will turn darker and the values in the boxes will turn light grey. The navigation key is moved to the left or right to select either Kcal of KJ.

To go back to the value boxes: press down on the navigation key. The Kcal and KJ option will turn light grey and the values in the value boxes will turn darker. The cursor will blink in the bottom value box.

5.4 IMPLEMENTATION DISCUSSION

The cellular phone chosen to support the software proved more than capable to fulfill the software requirements. Of particular concern was the phone's capability of handling the five expanding databases especially the logbook database. The logbook had to store up to six meals as well as the exercise, blood glucose and insulin information for each day of the evaluation period. The dynamic behavior of the databases introduces entropy to some extent into the information storage which could lead to instability.

A person's natural resistance towards trusting and learning to use a new software application can be greatly reduced by the user interface. If it is easy and not difficult for the user to recognize what is required, the person will feel more at ease using the software and better results will be obtained. The combination of text and icons in the dietary assistant user interface ensures that the user is always aware of what action to take to achieve the desired effect from the dietary assistant. The user interface does not only consist of the visual display, but encompasses everything the user must perform to interact with the software. To input data into the software must be as effortless as possible. The hardware input system is determined by the hardware platform used, in this case the Nokia 6600. The software was designed in such a way as to make efficient use of the phone's ergonomics for user input. The Nokia 6600 provides a multi-directional input navigation key, soft keys for easy navigation and the standard numerical and alpha numerical input keys. The dietary assistant makes full use of these keys for interaction between the software and the user.

Development through Microsoft Visual Basic proved fruitful in the sense that it requires very little effort to start off with. The required knowledge of the programming language is easily acquired as the development effort become more involved and complex. The Visual Basic language provides powerful methods to develop a graphical user interface driven application in a small amount of time. All the functionality required by the dietary assistant was provided for by Visual Basic.

Finally, the implementation of the dietary assistant proved to be a great success, as is further discussed in chapter 6.

CHAPTER 6

Results and Conclusion

6.1 INTRODUCTION

The first part of this chapter presents the results obtained at the completion of the study. The results presented in this study prove that the ets diet is a healthy and effective diet to follow for individuals that want to lose weight. The results also prove the concept of providing individuals with a user friendly digital dietary assistant for dietary control.

In the second part of this chapter the conclusions drawn from the results presented will be given and discussed.

6.2 CLINICAL RESULTS FOR ETS LIMITED DIET

This section gives a description of the statistical analysis done on obesity data provided by Dr P. Ackerman.

The data used for the analysis stretches from the year 2000 through 2004. The analysis was based on weight loss and waist circumference reduction to determine the effectiveness of the weight loss program. The patients considered consisted of both sexes and all ages, although female patients were more prevalent. Results are given as a general figure for all groups.

6.2.1 RESULTS OF ETS CLINICAL TRAIL

The results of the weight loss analysis are shown in Table 1 below. The average time period elapsed was 27 days.

Total sample size	686
Mean weight loss rate per week	564 g/week
Variance	565

Standard deviation	752
Mean weight before diet period	86 kg
Mean weight at time of analysis	82.2 kg

Table 6-1

The weight loss results

From the results shown in Table 6-1, it can be seen that in general a patient loses 564 grams each week while on the treatment.

The results for the reduction in waist circumference are shown in Table 6-2.
The average time period elapsed was 27 days.

Total sample size	677
Mean waist circumference reduction per week	0.746 cm/week
Variance	0.691
Standard deviation	0.831
Mean waist circumference before diet period	91.6 cm
Mean wais circumference at time of analysis	86 cm

Table 6-2

The waist reduction results

From the results shown in Table 6-1 it can be seen that in general a patient loses 0.746 cm off his/her waist each week while on the treatment.

Figure 6-1 and Figure 6-2 show the distribution graphs for the weight loss and waist reduction results respectively. These graphs give an indication of how the results are dispersed which illustrates what the typical best case and worst case results for a patient may be.

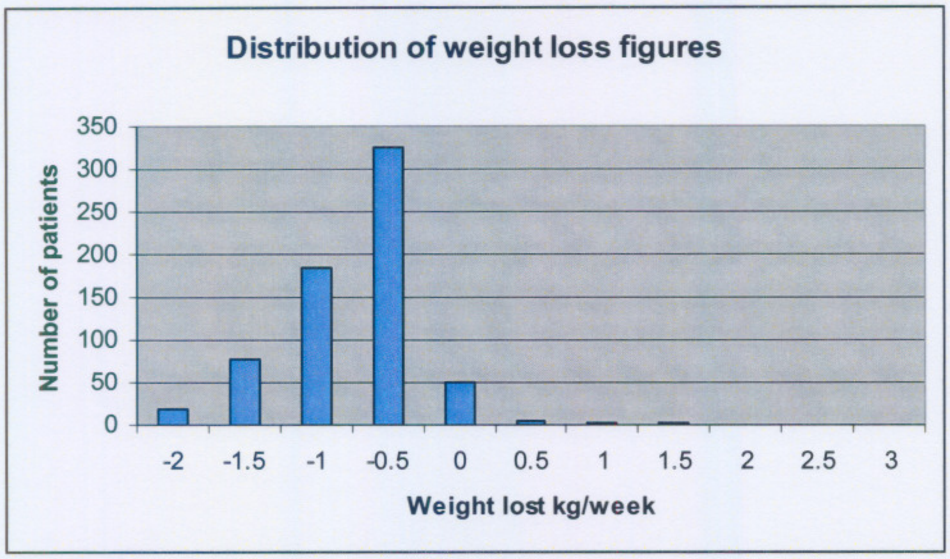

Figure 6-1

The distribution of the weight loss figures

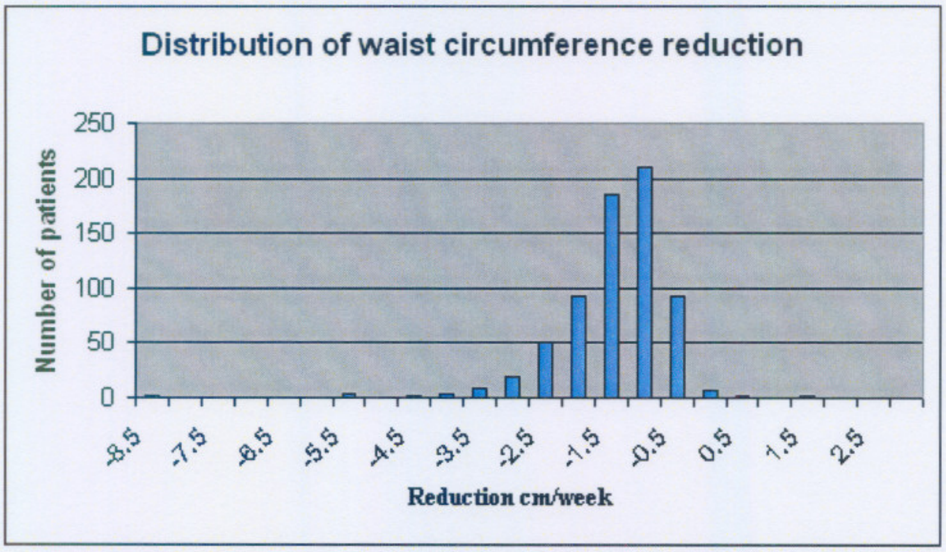

Figure 6-2
The distribution of waist circumference reduction figures

6.3 USER EVALUATION

In this section the user evaluation of the ets dietary assistant dietary assistant is presented. All the participants in the user evaluation were asked to evaluate the assistant in everyday use. The participants were asked to complete a user evaluation form after their evaluation period. Users were typically asked to make use the dietary assistant and afterwards complete a user evaluation form. An example of the user evaluation form can be found **Appendix B**.

6.3.1 USER SAMPLE COMPOSITION

Details on the composition of the user sample is given in this section.

Total number of users	26
Total number of male users	11
Total number of female users	15

Table 6-3

Total number of users

The graph below, figure 6-3, shows the age distribution of the users used in the study.

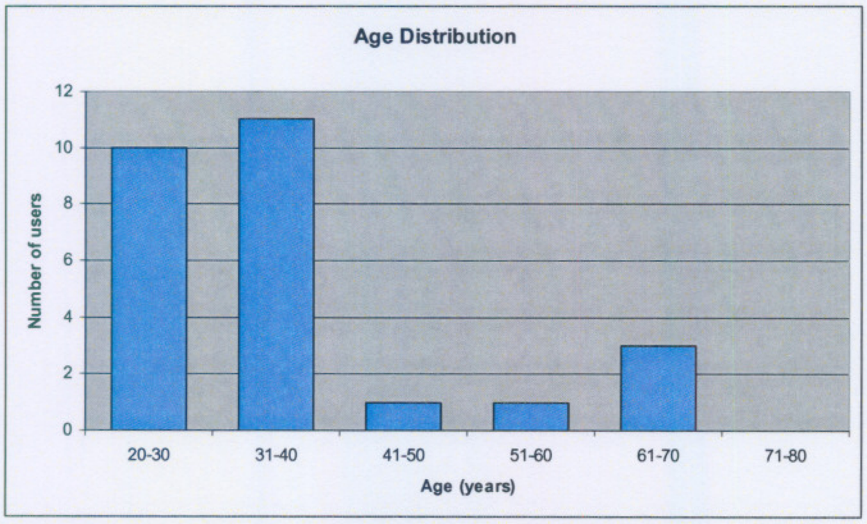

Figure 6-3

Distribution of users age groups

As can be seen from the graph in figure 6-3 most of the users involved in the evaluation lies between the ages of 20 and 40 years of age. There were also some older users between the ages of 55 and 65 whilst the least number were between the ages of 41 and 60. There were no users older than 70 who partook in the user evaluation.

6.3.1 OVERALL USER FEEDBACK

The results of the user feedback is presented in the table below. These are the overall results for all users. In the discussion of the results in later sections a separation will be made between male and female experiences with the ets dietary assistant.

Description	**Feedback Result**	
	Yes	**No**
1. Acceptance of new technology	77%	23%
2. Computer literacy	85%	15%
3. Health conscious about diet	73%	27%
4. Previous experience with diet plans	35%	65%
5. Previous experience with similar device	15%	85%
6. Ease of navigation	77%	
7. Ease of adding food/exercise entry	82%	
8. Completeness of food database	76%	
9. Completeness of exercise database	77%	
10. Evaluation of logbook	78%	
11. Results presentation to user	84%	
12. Regular use of cell phones	92%	8%
13. Cell phone ease of use	92%	8%
14. Accept assistant for personal use	62%	38%
15. Recommend assistant to other users	92%	8%

Table 6-4

Overall user feedback results

In the following sections the results given in table 6-4 is discussed in more detail. The results is presented in three parts:

- User classification, question one to five of table 6-4.
- User experience, question six to eleven of table 6-4.
- User acceptance, question twelve to fifteen of table 6-4.

Table 6-4 presents the results as an overall interpretation, in the following sections however the results will be divided between male and female feedback. The opposite sexes view of health and technology makes for interesting comparison on some issues.

6.3.1.1 USER CLASSIFICATION

The user classification shows how the users involved in the study see themselves with regards to technology, diets and previous experience. This is useful to see what the user's initial resistance to the new ets dietary assistant may be and how they may interpret the usefulness of the ets dietary assistant. The user classification corresponds to questions one through five of the user evaluation form which is also numbers one through five of table 6-4.

Question 1

Do you consider yourself a person that works well with new technology?

The response to this question is presented below.

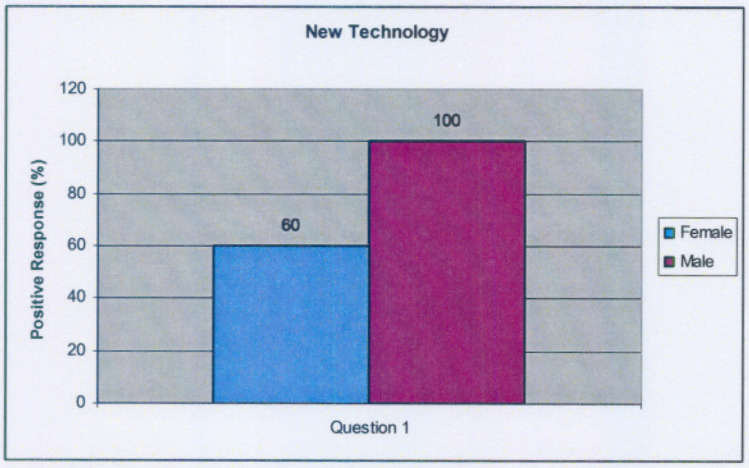

Figure 6-4

User responses to Question 1

It is shown in figure 6-4 that 60% of the woman felt that they worked well with new technology against 100% of the men.

Question 2

Does your profession involve the use of computers on a daily basis?

The response to this question is presented below.

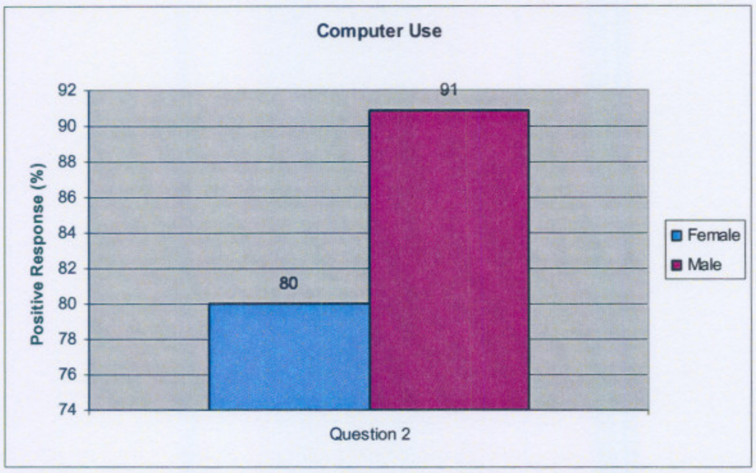

Figure 6-5

User responses to Question 2

It is shown in figure 6-5 that 80% of the woman make use of computers on a daily basis in their profession against 91% of the men.

Question 3

Are you generally concerned about following a healthy diet?

The response to this question is presented below.

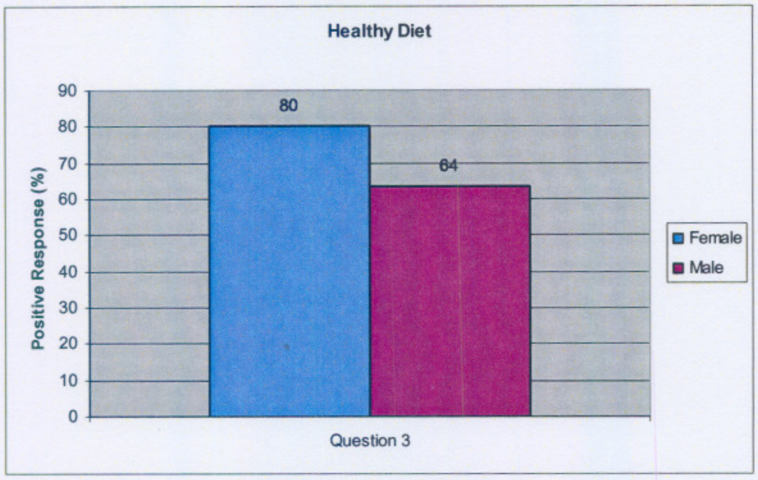

Figure 6-6

User responses to Question 3

It is shown in figure 6-6 that 64% of the men are concerned about following a healthy diet against 80% of the woman.

Question 4

Have followed a controlled eating plan before?

The response to this question is presented below.

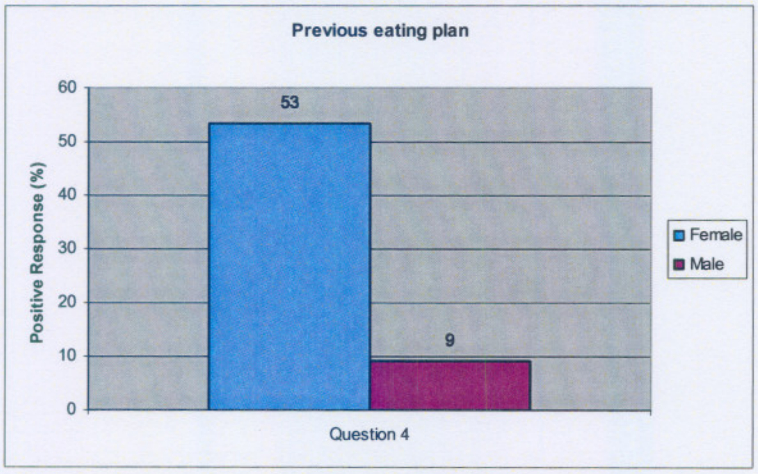

Figure 6-7

User responses to Question 4

It is shown in figure 6-7 that 9% of the men have followed a controlled eating plan before against 53% of the woman.

Question 5

Have you made use of a similar program/device before?

The response to this question is presented below.

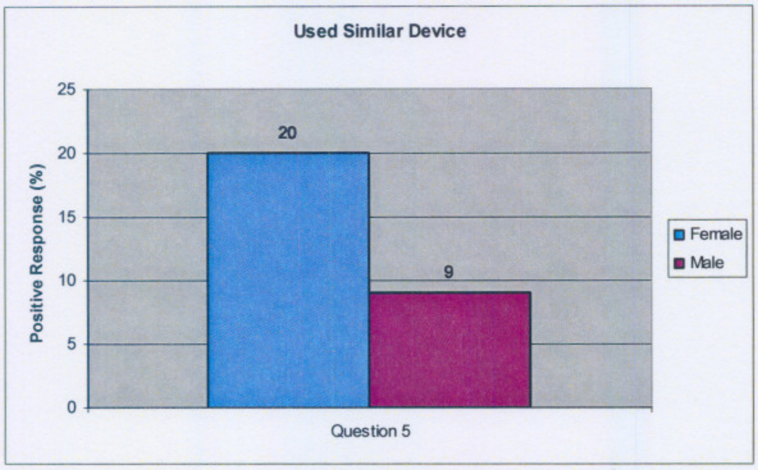

Figure 6-8

User responses to Question 5

It is shown in figure 6-8 that 9% of the men have used a similar program/device before against 20% of the woman.

6.3.1.2 USER EXPERIENCE

The user experience relates how the users experienced the operation and ease-of-use of the ets dietary assistant. These results are from questions six to eleven of the evaluation form, numbers six to eleven in table 6-4.

The results in this section are presented differently than in the previous section. The absolute overall user rating will first be presented. This is to give an indication of the distribution of the user rating for each question. The overall average user rating will be presented to show how any user might rate the ets dietary assistant. Lastly the male and female average ratings will be presented to show the differences in male and female interpretations taking into consideration what was learned in the previous section.

The users were asked to rate the ets dietary assistant by answering the following questions:

- (6) Did you find it quick and easy to navigate through the menus and options of the ets-dietary assistant?
- (7) Did you find it quick and easy to find items in the food and exercise databases?
- (8) Do you consider the food database to be thorough and complete?
- (9) Do you consider the exercise database to be thorough and complete?
- (10) Do you consider the information presented in the logbook as relevant and easily accessible?
- (11) Did you find it easy to interpret the dietary information presented by the ets dietary assistant? For example: The amount of nutritional value consumed for the day vs. the amount still available.

All the questions carry a rating of one to five where five is the highest rating and one the lowest rating.

User rating distribution

The graph in figure 6-9 shows how each of the different aspects of the ets dietary assistant was rated by all users.

The ratings are distributed around four with ratings of either four, three or five. There only in sections eight and ten are there also some ratings of two. No user rated any of the sections for one.

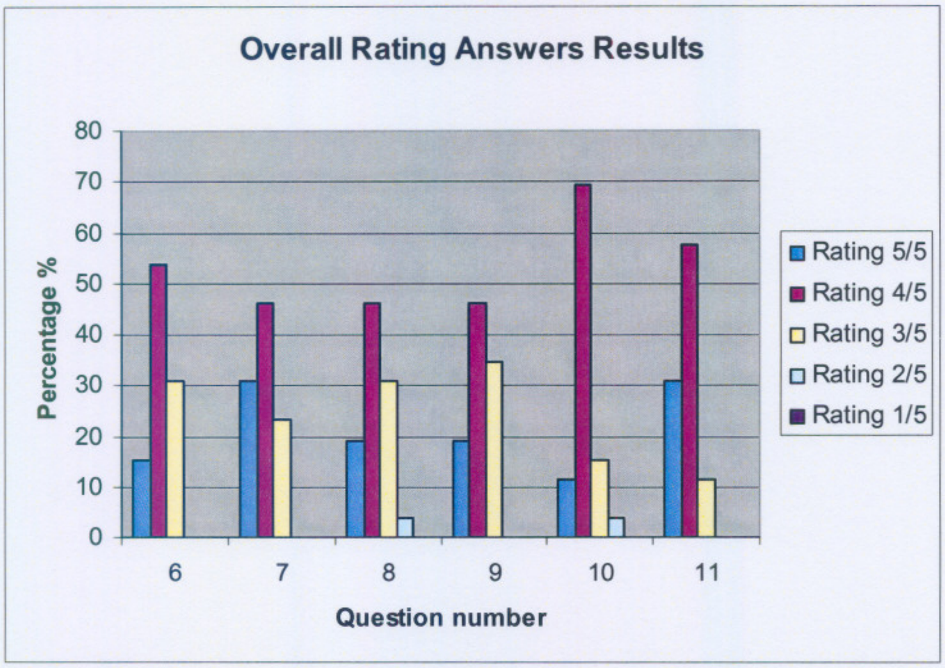

Figure 6-9

Individual Ratings

Figure 6-10 shows the average rating of the ets dietary assistant. All the distributions shown in figure 6-9 are averaged to arrive at the graph. The average rating of the ets dietary assistant shows the highest average rating of 53% at four out of five. The ratings of three and five out of five are almost equal at 24% and 21% respectively. Only 1% of the ratings are at two out of five.

Figure 6-10

Average Rating Distribution

Average Ratings

Figure 6-11 shows the average ratings for each category out of five. The final red bar in the graph shows the average rating over all the categories. All the ratings are higher than 3.8 the highest rating is 4.19 for category 11 and the lowest 3.81 for category 8. The average rating is 3.94 which is an rating of 78.8%.

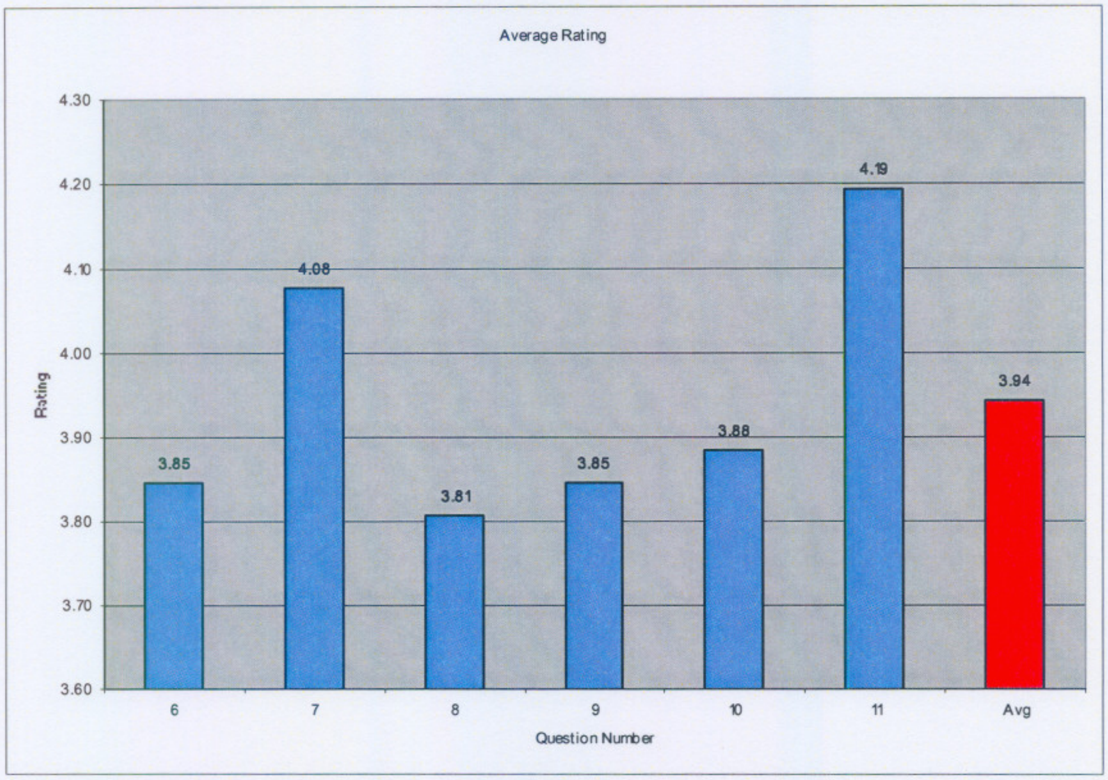

Figure 6-11

The user rating results

Figure 6-12 shows the average ratings of male and female users. As can be seen from the graph male and female users rate the ets dietary very similarly. The female users rated the ets dietary assistant a small margin higher than the male users except for category eight where the difference is negligible. The average rating by female users is shown by the yellow bar and the average rating by male users is shown by the green bar. The average female rating is 4.04 (80.8%) and the average male rating 3.8 (76%).

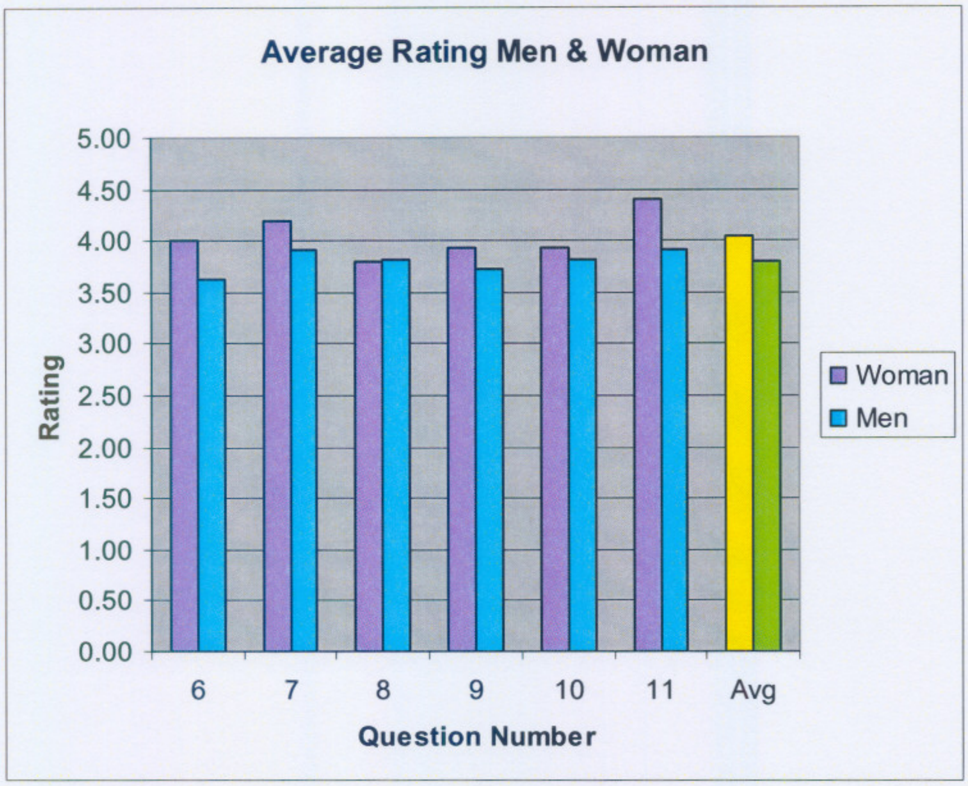

Figure 6-12

Average rating of male and female users

6.3.1.3 USER ACCEPTANCE

The user acceptance results is based on questions twelve to fifteen of the user evaluation form, numbers twelve to fifteen in table 6-4.

Though the results for the user acceptance it is shown ultimately if the user found the ets dietary assistant easy to use and trusted the information presented by the device.

Question 12

Do you carry a cellular phone with you on a regular basis?

The response to this question is presented below.

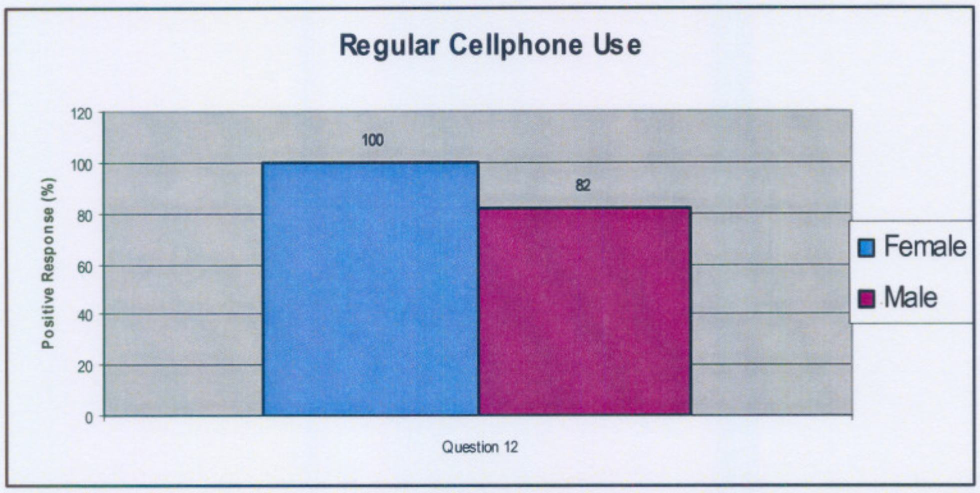

Figure 6-13

User responses to Question 12

It is shown in figure 6-13 that 82% of the men carry a cellular phone on a daily basis against 100% of the woman.

Question 13

Did you find it easy to use the cellular phone itself?

The response to this question is presented below.

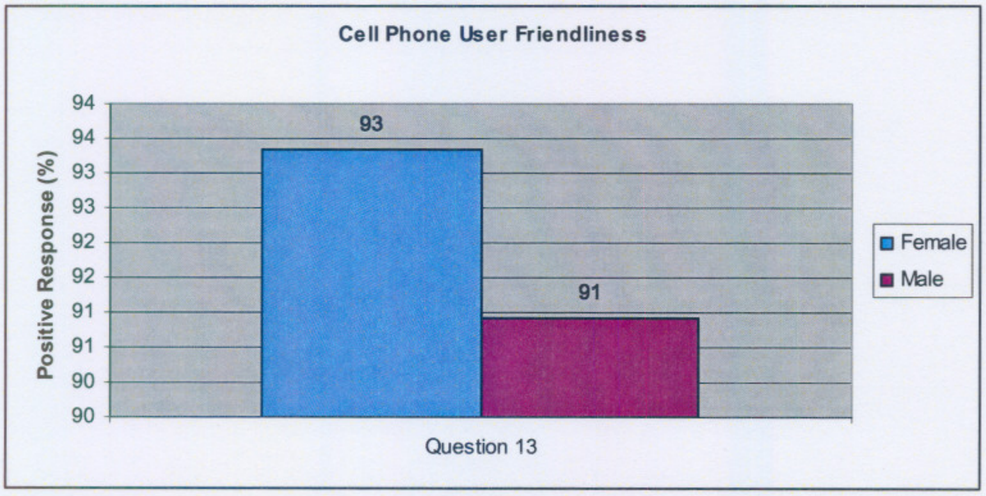

Figure 6-14

User responses to Question 13

It is shown in figure 6-14 that 91% of the men found the cellular phone easy to use against 93% of the woman.

Question 14

Would you consider using the ets-bolus dietary assistant on a regular basis?

The response to this question is presented below.

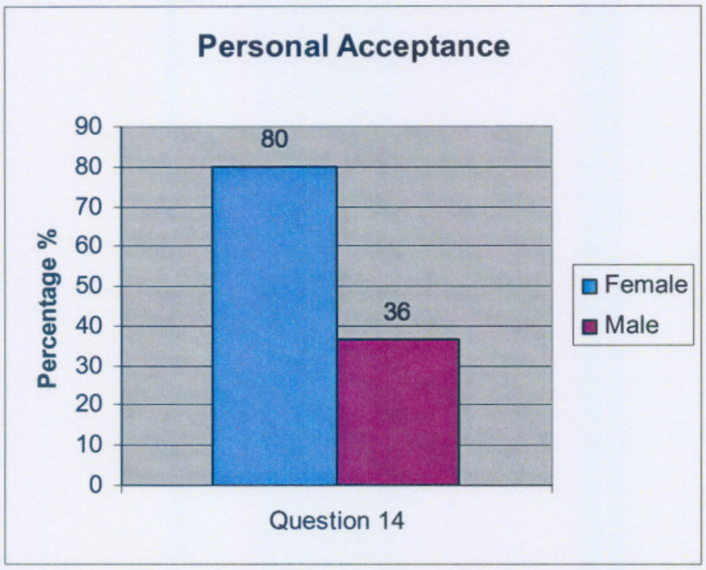

Figure 6-15

User responses to Question 14

It is shown in figure 6-15 that 36% of the men would consider using the ets dietary assistant on a regular basis against 80% of the woman.

Question 15

Would you recommend the ets-bolus dietary assistant to other users?

The response to this question is presented below.

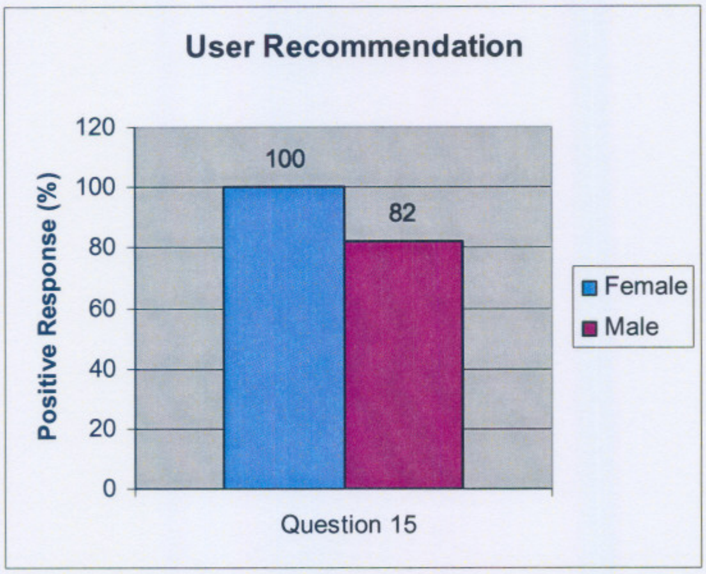

Figure 6-16

User responses to Question 15

It is shown in figure 6-16 that 82% of the men would recommend the ets dietary assistant to other people against 100% of the woman.

6.4 CONCLUSIONS

The conclusions to the study is presented in this section. The conclusion follows on as a discussion of the results presented in section 6.2 and 6.3.

6.4.1 ETS LIMITED DIET

As can be seen from the results presented in section 6.2 the patients that used an ets limited diet showed positive results. Most of the patients experienced healthy weight loss figures and equally impressive waist circumference reduction figures.

These results proves that the insulin limited ets diet does work. Based on the results of the six hundred plus patients evaluated over a four year period it can be confidently stated that if a person follows the ets limited diet that a person will lose weight. The ets limited diet thus provides an effective tool in combating the epidemic of obesity that the world is currently faced with.

A person can by reducing the amount of energy consumed on a daily basis improve his/her health. All that is required is to follow a simple disciplined diet and not exceed the recommended daily allowance of energy intake.

6.4.2 USER EVALUTION

Looking at the overall user evaluation presented in section 6.3 the evaluation of the ets dietary assistant is favourable. Based on the feedback there is a definite space in the market for an software application like the ets dietary assistant. Most of the users were very enthusiastic about the ets dietary assistant but a few felt that there are still something here and there that is missing for their specific needs.

6.4.2.1 USER CLASSIFICATION

Interestingly the female participants in the user evaluation considered themselves to much less friendly to new technologies than their male counterparts. The female users were also slightly less involved with computers in their professions. This apparent technology gap between the sexes did not seem to have a large influence on the evaluation of the ets dietary assistant as they rated it almost equally.

The female participants were more concerned with following healthy diets than the male participants although most of the users were still concerned with eating a healthy diet.

The number of female participants that have used an controlled eating plan before by far outstretched the number of male participants.

Very few of the users involved in this evaluation have made use of a similar device in the past.

From what is seen in the user classification it can be concluded that the users are technologically enabled and computer literate. The female users have more experience in following eating plans and are more concerned with what they eat than the male users.

6.4.2.2 USER EXPERIENCE

The users experienced the ets dietary assistant in a favourable light. With the average rating of a little under eighty percent. The female users rated the ets dietary assistant slightly higher than the male users. This may be due to the fact that the female users have more experience in following diets or that the male users are more technically literate. The difference in the rating results are so small that it does not effect the overall results for the ets dietary assistant.

Some feedback suggested that the exercise database does not present enough options for people that are interested more in keeping a training logbook than an eating logbook. This feedback presented an interesting alternative to increase the efficiency of the ets dietary assistant to incorporate a training assistant since diet and training is closely linked to each other.

Although the average user rating is a good one there are some areas that the users did not find as inviting as was hoped. The main menu received a high number of ratings for three out of five similarly the access method to the data bases and completeness of the databases also received a high number of three out of five ratings.

6.4.2.3 USER ACCEPTANCE

The users found the cellular phone used as an implementation platform easy to use.

Most of the female users would consider using the ets dietary assistant on a regular basis to assist them with their diet. Only a third of the male users would consider using the ets dietary assistant on a regular basis. These results are to be expected when the number of male users concerned about their diets and the number of male users that have been on a controlled eating plan before is taken into account. Almost all of the users will recommend the ets dietary assistant to other users that they feel will benefit from the device.

In conclusion it can be seen that the ets dietary assistant will most likely gain a large following of female supporters. It can be said that the ets dietary assistant does inspire confidence in the users as most of them would recommend the ets dietary assistant to other users.

6.4.3 FINAL CONCLUSION

As a final conclusion to this study the study objectives of section 1.4 is discussed an concluded.

First Objective:

Show the effectiveness of the ets dietary concept through limiting energy intake. This objective will be proven by a weight loss experiment.

Results illustrating the success of an ets limited diet was presented in section 6.2. The objective was comfortably met with good success. This proves that the ets concept is a valid and effective energy limiting concept. The ets concept is also validated for use as the basis for the dietary assistant.

Second Objective:

To provide a practical implementation of the dietary assistant. This application must provide accurate and useful information.

The practical implementation was realised successfully according to chapter 4 and chapter 5 which provides the details on the design and implementation of the ets dietary assistant. The realised implementation was presented to a number of different users with favourable reactions. The user feedback in section 6.3 shows that the users found the ets dietary assistant to be acceptable.

The second objective of this study was also successfully met.

Third Objective:

Show the user acceptance of the dietary assistant. Through using the dietary assistant users will provide feedback of their personal experience.

The results shown in section 6.3 show the results of the user feedback. As can be seen the user acceptance of the ets dietary assistant was high with most of the users being impressed by the concept and ease-of-use of the ets dietary assistant. Thus, the third and final, objective of the study is also successfully met.

6.5 RECOMMENDATIONS FOR FUTURE WORK

This study laid a foundation for using a new energy measurement technique integrated into an everyday digital delivery platform in the from of a dietary assistant. Below is listed a few points for future study to improve and evolve the current knowledge gained from this study.

- The revolutionary new energy quantification method for used for measuring the energy in food, ets, used in this study is a research subject that is still very new and forthcoming. The ets concept as described here relates only to the energy gained from carbohydrates. This approach to energy quantification already proved to be successful during this study. The ets concept may still be further enhanced by integrating the effect of fat and protein in food which at this point is assumed to have no effect although this is not true.

- In its current form the dietary assistant will only function on a series 60 platform device. This platform is no longer on the forefront of the technology wave. The dietary assistant must be made more generic in order to reach a wider user base across different platforms of devices. Porting the application software to a Java base may be one way of achieving this goal.

- For the feedback gathered from users during the user evaluation period of the study it was clear that there exist a desire for a more specialized assistant that is more focused towards the serious sports person. The dietary assistant may me modify to assist these users in working on a training program which include their diet and exercise.

- Dentitions may need to dietary assistant to provide more analysis capabilities especially if a record is kept over and extended period of time. The analysis may extend onto custom tools developed on a desktop environment to interface with the dietary assistant.
- Currently it is not a trivial issue to upgrade the databases contained on the mobile platform that the dietary assistant runs on. A method of upgrading the database files via an internet connection form an end user perspective may prove to be a very useful addition to the dietary calculator.

CHAPTER 8

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8.1 REFERENCES

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APPENDIX A

ETS RDA NUTRITIONAL TABLES

A.1 ETS RDA NUTRITIONAL TABLES

	Height (m)	Weight (kg)	ets
Men	1.2 - 1.25	33 - 38	39
	1.25 - 1.3	36 - 41	42
	1.3 - 1.35	38 - 44	45
	1.35 - 1.4	42 - 48	50
	1.4 - 1.45	44 - 50	52
	1.45 - 1.5	47 - 54	55
	1.5 - 1.55	50 - 58	60
	1.55 - 1.6	54 - 62	64
	1.6 - 1.65	56 – 65	66
	1.65 - 1.7	59 – 68	70
	1.7 - 1.75	63 – 73	75
	1.75 - 1.8	66 – 77	79
	1.8 - 1.85	70 – 82	84
	1.85 - 1.9	74 – 86	89
	1.9 - 1.95	77 – 90	92
	1.95 - 2	81 – 94	96
	2 - 2.05	85 - 100	102
	2.05 - 2.1	89 - 104	107
	2.1 - 2.15	93 - 109	112
	2.15 - 2.2	96 - 114	116
	2.2 - 2.25	100 - 120	122
Women	1.2 - 1.25	33 - 38	39
	1.25 - 1.3	35 - 41	42
	1.3 - 1.35	37 - 44	44
	1.35 - 1.4	40 - 46	48
	1.4 - 1.45	43 - 50	52
	1.45 - 1.5	45 - 53	54
	1.5 - 1.55	47 - 55	56
	1.55 - 1.6	50 - 59	61
	1.6 - 1.65	53 - 63	64
	1.65 - 1.7	56 - 67	68
	1.7 - 1.75	60 - 70	72
	1.75 - 1.8	63 - 73	75
	1.8 - 1.85	66 - 77	79
	1.85 - 1.9	68 - 81	83
	1.9 - 1.95	72 - 85	86
	1.95 - 2	76 - 89	91
	2 - 2.05	79 - 93	95
	2.05 - 2.1	82 - 97	99

Table A1 ets RDA for active people

	Height (m)	Weight (kg)	ets
Men	1.2 - 1.25	33 - 38	33
	1.25 - 1.3	36 - 41	36
	1.3 - 1.35	38 - 44	39
	1.35 - 1.4	42 - 48	43
	1.4 - 1.45	44 - 50	45
	1.45 - 1.5	47 - 54	48
	1.5 - 1.55	50 - 58	52
	1.55 - 1.6	54 - 62	55
	1.6 - 1.65	56 - 65	57
	1.65 - 1.7	59 - 68	60
	1.7 - 1.75	63 - 73	65
	1.75 - 1.8	66 - 77	68
	1.8 - 1.85	70 - 82	72
	1.85 - 1.9	74 - 86	76
	1.9 - 1.95	77 - 90	79
	1.95 - 2	81 - 94	83
	2 - 2.05	85 - 100	88
	2.05 - 2.1	89 - 104	93
	2.1 - 2.15	93 - 109	96
	2.15 - 2.2	96 - 114	100
	2.2 - 2.25	100 - 120	105
Women	1.2 - 1.25	33 - 38	33
	1.25 - 1.3	35 - 41	36
	1.3 - 1.35	37 - 44	38
	1.35 - 1.4	40 - 46	41
	1.4 - 1.45	43 - 50	45
	1.45 - 1.5	45 - 53	47
	1.5 - 1.55	47 - 55	49
	1.55 - 1.6	50 - 59	52
	1.6 - 1.65	53 - 63	55
	1.65 - 1.7	56 - 67	58
	1.7 - 1.75	60 - 70	62
	1.75 - 1.8	63 - 73	65
	1.8 - 1.85	66 - 77	68
	1.85 - 1.9	68 - 81	72
	1.9 - 1.95	72 - 85	74
	1.95 - 2	76 - 89	78
	2 - 2.05	79 - 93	82
	2.05 - 2.1	82 - 97	85

Table A2 ets RDA for normal activity levels

	Height (m)	Weight (kg)	ets
Men	1.2 - 1.25	33 - 38	29
	1.25 - 1.3	36 - 41	32
	1.3 - 1.35	38 - 44	34
	1.35 - 1.4	42 - 48	37
	1.4 - 1.45	44 - 50	39
	1.45 - 1.5	47 - 54	42
	1.5 - 1.55	50 - 58	45
	1.55 - 1.6	54 - 62	48
	1.6 - 1.65	56 - 65	50
	1.65 - 1.7	59 - 68	52
	1.7 - 1.75	63 - 73	56
	1.75 - 1.8	66 - 77	59
	1.8 - 1.85	70 - 82	63
	1.85 - 1.9	74 - 86	66
	1.9 - 1.95	77 - 90	69
	1.95 - 2	81 - 94	72
	2 - 2.05	85 - 100	76
	2.05 - 2.1	89 - 104	81
	2.1 - 2.15	93 - 109	84
	2.15 - 2.2	96 - 114	87
	2.2 - 2.25	100 - 120	91
Women	1.2 - 1.25	33 - 38	29
	1.25 - 1.3	35 - 41	32
	1.3 - 1.35	37 - 44	33
	1.35 - 1.4	40 - 46	36
	1.4 - 1.45	43 - 50	39
	1.45 - 1.5	45 - 53	41
	1.5 - 1.55	47 - 55	42
	1.55 - 1.6	50 - 59	46
	1.6 - 1.65	53 - 63	48
	1.65 - 1.7	56 - 67	51
	1.7 - 1.75	60 - 70	54
	1.75 - 1.8	63 - 73	56
	1.8 - 1.85	66 - 77	59
	1.85 - 1.9	68 - 81	62
	1.9 - 1.95	72 - 85	65
	1.95 - 2	76 - 89	68
	2 - 2.05	79 - 93	71
	2.05 - 2.1	82 - 97	74

Table A3 ets RDA for light activity levels

	Height (m)	Weight (kg)	ets
Men	1.2 - 1.25	33 - 38	24
	1.25 - 1.3	36 - 41	26
	1.3 - 1.35	38 - 44	28
	1.35 - 1.4	42 - 48	30
	1.4 - 1.45	44 - 50	32
	1.45 - 1.5	47 - 54	34
	1.5 - 1.55	50 - 58	37
	1.55 - 1.6	54 - 62	39
	1.6 - 1.65	56 - 65	41
	1.65 - 1.7	59 - 68	43
	1.7 - 1.75	63 - 73	46
	1.75 - 1.8	66 - 77	48
	1.8 - 1.85	70 - 82	51
	1.85 - 1.9	74 - 86	54
	1.9 - 1.95	77 - 90	56
	1.95 - 2	81 - 94	59
	2 - 2.05	85 - 100	62
	2.05 - 2.1	89 - 104	66
	2.1 - 2.15	93 - 109	68
	2.15 - 2.2	96 - 114	71
	2.2 - 2.25	100 - 120	74
Women	1.2 - 1.25	33 - 38	24
	1.25 - 1.3	35 - 41	26
	1.3 - 1.35	37 - 44	27
	1.35 - 1.4	40 - 46	29
	1.4 - 1.45	43 - 50	32
	1.45 - 1.5	45 - 53	33
	1.5 - 1.55	47 - 55	35
	1.55 - 1.6	50 - 59	37
	1.6 - 1.65	53 - 63	39
	1.65 - 1.7	56 - 67	41
	1.7 - 1.75	60 - 70	44
	1.75 - 1.8	63 - 73	46
	1.8 - 1.85	66 - 77	48
	1.85 - 1.9	68 - 81	51
	1.9 - 1.95	72 - 85	53
	1.95 - 2	76 - 89	56
	2 - 2.05	79 - 93	58
	2.05 - 2.1	82 - 97	60

Table A4 ets RDA for weight losers

APPENDIX B

USER EVALUATION QUESTIONNAIRE

Human-Sim ets-bolus dietary assistant questionnaire

Please complete the following questionnaire with regard to the Human-Sim ets-bolus dietary assistant. A great amount of effort and time was invested into making the ets-bolus dietary assistant as user-friendly and relevant as possible. Through this questionnaire we ask for your assistance and feedback to help with the assessment and improvement of the ets-bolus dietary assistant.

Thank you for your time and effort with this questionnaire.

1 . PERSONAL INFORMATION

Name and Surname : ______________________________

Birth date (yyyy/mm/dd):______________________________

Gender: ☐ Male ☐ Female

2. FEEDBACK

Question 1

Do you consider yourself a person that works well with new technology?

☐ Yes.

☐ No.

> Are cell phones and PDA's stumbling blocks or useful devices. Are you computer literate?

Question 2

Does your profession involve the use of computers on a daily basis?

☐ Yes.

☐ No.

> Are you fluent in using the internet and email? Do you know what a database is?

Question 3

Are you generally concerned about following a healthy diet?

☐ Yes.

☐ No.

Do you stay away from fast food? Do your try to eat a balanced meal?

Question 4

Have followed a controlled eating plan before?

☐ Yes.

☐ No.

Have you or are you following a prescribed dieting plan?

Question 5

Have you made use of a similar program/device before?

☐ Yes.

☐ No.

Please tick the applicable option and provide a short description or name of the device/program

____

____

____

____

____

Question 6

Did you find it quick and easy to navigate the through the menus and options of the ets-dietary assistant?

- ☐ 5. Extremely
- ☐ 4. Very
- ☐ 3. Moderately
- ☐ 2. Slightly
- ☐ 1. Not at all

Please tick the applicable rating from 1-5. 5 being the most and 1 the least. Please write any comments in the space provided.

Question 7

Did you find it quick and easy to find items in the food and exercise databases?

- ☐ 5. Extremely
- ☐ 4. Very
- ☐ 3. Moderately
- ☐ 2. Slightly
- ☐ 1. Not at all

Please tick the applicable rating from 1-5. 5 being the most and 1 the least. Please write any comments in the space provided.

Question 8

Do you consider the food database to be thorough and complete?

- ☐ 5. Extremely
- ☐ 4. Very
- ☐ 3. Moderately
- ☐ 2. Slightly
- ☐ 1. Not at all

Please tick the applicable rating from 1-5. 5 being the most and 1 the least. Please write any comments in the space provided.

Question 9

Do you consider the exercise database to be thorough and complete?

- ☐ 5. Extremely
- ☐ 4. Very
- ☐ 3. Moderately
- ☐ 2. Slightly
- ☐ 1. Not at all

Please tick the applicable rating from 1-5. 5 being the most and 1 the least. Please write any comments in the space provided.

Question 10

Do you consider the information presented in the logbook as relevant and easily accessible?

- ☐ 5. Extremely
- ☐ 4. Very
- ☐ 3. Moderately
- ☐ 2. Slightly
- ☐ 1. Not at all

Please tick the applicable rating from 1-5. 5 being the most and 1 the least. Please write any comments in the space provided.

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Question 11

Did you find it easy to interpret the dietary information presented by the ets-bolus dietary assistant? For example: The amount of nutritional value consumed for the day vs. the amount still available.

- ☐ 5. Extremely
- ☐ 4. Very
- ☐ 3. Moderately
- ☐ 2. Slightly
- ☐ 1. Not at all

Please tick the applicable rating from 1-5. 5 being the most and 1 the least. Please write any comments in the space provided.

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Question 12

Do you carry a cellular phone with you on a regular basis?

☐ Yes.

☐ No.

Please tick yes or no.

Question 13

Did you find it easy to use the cellular phone itself?

☐ Yes.

☐ No.

Please tick yes or no. If you have any comment please write it down in the space provided.

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Question 14

Would you consider using the ets-bolus dietary assistant on a regular basis?

☐ Yes.

☐ No.

Please tick yes or no.

Question 15

Would you recommend the ets-bolus dietary assistant to other users?

☐ Yes.

☐ No.

Please tick yes or no.

- END -

APPENDIX C

DIETARY ASSISTANT USER MANUAL

Question 10

Do you consider the information presented in the logbook as relevant and easily accessible?

- ☐ 5. Extremely
- ☐ 4. Very
- ☐ 3. Moderately
- ☐ 2. Slightly
- ☐ 1. Not at all

Please tick the applicable rating from 1-5. 5 being the most and 1 the least. Please write any comments in the space provided.

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- ☐ 3. Moderately
- ☐ 2. Slightly
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☐ No.

Please tick yes or no.

Question 15

Would you recommend the ets-bolus dietary assistant to other users?

☐ Yes.

Please tick yes or no.

☐ No.

- END -

APPENDIX C

DIETARY ASSISTANT USER MANUAL

HumanSim (PTY) LTD Simulation of the Human Body

User Guide

Ets Dietary Assistant

Version 1.1

For Nokia 6600

1. Table of Contents

1. INTRODUCTION

Welcome to the Ets dietary assistant user guide. This guide will assist you in using the Ets dietary assistant on the Nokia 6600 cell phone. Please refer to the support sections of this document should you experience any difficulty in using the Ets dietary assistant .

The user guide provides step by step instructions on the operation of the Ets dietary assistant . Please take a moment to read through the guide to ensure that an understanding of the Ets dietary assistant is gained and the operation thereof.

The Ets dietary assistant can only be of use if it is supplied with all the dietary and exercise information continuously. Please take the time to enter these events as they happen into the Ets dietary assistant .

The Ets dietary assistant team at Human-Sim hope that you will find the Ets dietary assistant useful and easy to use!

2. GETTING STARTED

2.1 NOKIA 6600 CELL PHONE BASICS

Your Nokia 6600 Cell phone

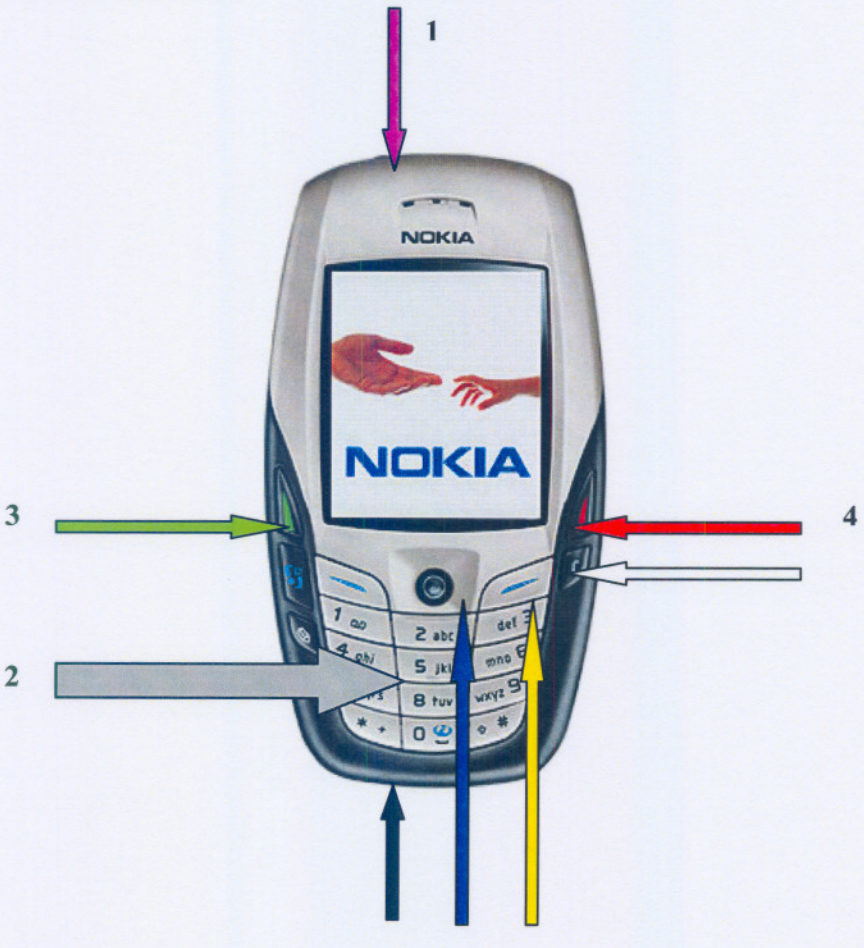


Figure 1

The Nokia 6600 cell phone

2.1.1 Switching on the telephone and entering the PIN number

Before you'll be able to use the Nokia 6600 you must switch on the phone. The power button is indicated by the purple arrow (1) in figure 1. Press the power button, indicated by a red circle on the telephone. Hold the button down until the display lights up. The NOKIA logo will appear after which you'll be asked to enter the PIN code. Enter your PIN code (provided by your service provider Vodacom, MTN or Cell C) followed by the # key. You should now be able to start using the telephone.

2.1.2 Charging the telephone

There are two indicators in the upper corners of the display. The graphic to the left shows the reception strength. The graphic on the right indicates how much charge is left on the battery.

When the battery is fully charged the graphic will display seven bars. Should the graphic only display two bars the battery must be recharged. The battery can be recharged by inserting the charging jack into the telephone as indicated by the black arrow (6) in figure 1. Please ensure that the battery is busy recharging by looking at the battery charge indicator on the display. The bars of the graphic in the top right corner of the display should be pulsing upwards.

2.1.3 Placing and receiving telephone calls

When you want to place a telephone call you will first need to enter the telephone number. The telephone number may either be entered manually or by selecting a contact from the telephone's built in address book. Please refer the section below to determine how to enter new contacts into the address book.

Entering a telephone number manually

To enter a telephone number manually the number keypad must be used. The keypad is shown in figure 1 by the grey arrow (2). Always remember to enter the area code for the telephone number as well. For example if you want to dial a number in Pretoria: 012 991 5110, you must enter the entire number 0129915110. If an error was made during the number entry, you may delete the number last entered by pressing the clear key shown in figure 1 by the white arrow (5). Verify that the correct number was erased by looking at the number shown on the display. The number will be displayed on the display as it is entered. When you have completed the number simply press the green dial button shown in figure 1 by the green arrow (3). The display will change indicating that a call is being made. There will be a slightly longer delay than on a land line phone before the dialled number will start ringing.

Entering a telephone number from the address book

Note*

A telephone number may be saved in the telephone address book and used again later when a call must be made to that number. The number must be entered manually into the address book and thereafter it can be used as a permanent contact.

To gain access to your address book press the button that is shown by the yellow arrow (7) in figure 1. You will notice the display shows the word 'Contacts' above this key. This is an indication of what function the key will perform. A list of names will be displayed when the key is pressed. At the bottom of the display there will be an area available to type a name or letter. This area is indicated by a blinking cursor at the left most position of the area. You may select a name by using the joystick, indicated in figure 1 by the blue arrow (8), or by searching for a name in the address book. **See figure 2 for to see the operation of the joystick.**

Entering a telephone number using the joystick

Please refer to the section below on how to use the joystick. You will be able to scroll through the entire list of contacts by moving the joystick either upwards or downwards. The current contact selected will be highlighted. When you've found the name that you wish to contact, please ensure that it is highlighted, and simply press the green dial button as shown in figure 1 by the green arrow (2). The display will show that the number is being dialled.

Searching for a name in the address book

A specific name may be searched for directly in the address book. This option allows you to go directly to the name that you are looking for without having to scroll through the entire contacts list. Please refer to the section below on how to enter text into a text box. After you have opened the contact list you may enter text into the search field on the bottom the display. You need only enter the first letter of the name you are looking for. All the names that start with that particular letter will be displayed in the list. You may scroll to the desired name using the joystick by either pushing it forward or backward. When you've found the name that you wish to contact, please ensure that it is highlighted, and simply press the green dial button as shown in figure 1 by the green arrow (2). The display will show that the number is being dialled.

After and terminating a telephone call

After a telephone conversation has been completed press the red button, shown by the red arrow (4) in figure 1. This will "hang-up" the line and terminates the telephone call.

2.1.4 Using the joystick

Figure 2

The Nokia 6600 joystick operation

Figure 2 shows the joystick and the four directions it can be moved towards. It may be used to scroll to the left, right, forward and backward directions. The button may be pressed inwards to select a specific highlighted function on the phone.

The joystick is used to scroll through the menus on the Nokia 6600 and to navigate the phone's functions.

2.1.5 The selection keys

Figure 3

The Nokia 6600 selection keys

The Nokia 6600 makes use of two selection keys. These selection keys are used to access additional functions. The function accessible through each selection key is shown by a label on the display, just above the individual key. Press the individual selection key to access the function indicated on the display.

2.1.6 Entering text information

Text information is any information that must be supplied to the telephone by the user.

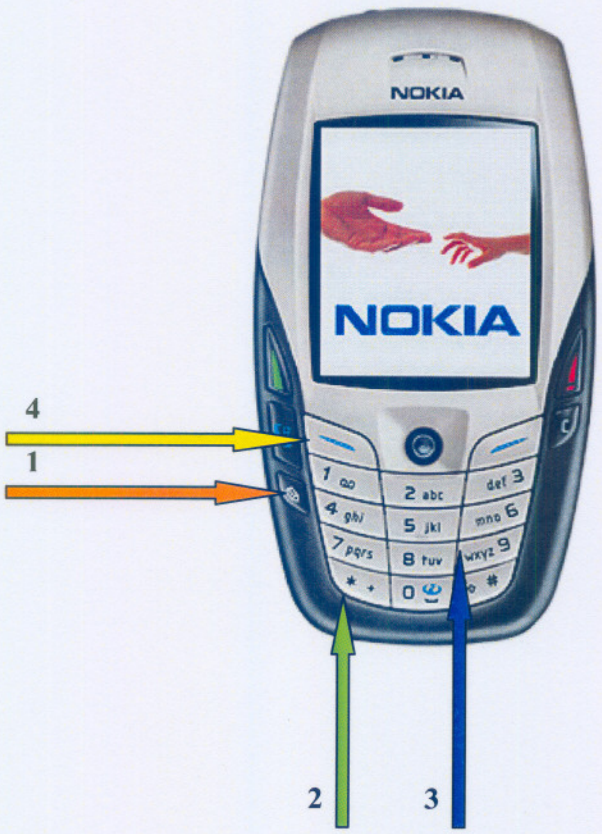


Figure 4

The Nokia 6600

Using the keypad to enter text information

Each of the numbers on the key pad also represents a number of letters in the alphabet. For example the '9' key (shown in figure 4 by the blue (3) arrow) have the letters WXYZ printed on it, this indicates that this key may be used to enter one of these four letters: W, X, Y or Z. The individual letters are reached in sequence when the button is pressed for example if the letter 'W' must be entered simply press the button once whilst if 'Y' is desired the button must be pressed four times and for 'Z' five times. This procedure holds for all the other keys with numbers and letters on the same key.

To enter non alphabetic characters press the '*' key as shown in figure 4 by the green arrow (2). When the '*' key is pressed a menu with all the available non alphabetic characters will be shown. The joystick is used to move from one character to the other. Once the desired character is reached press the joystick inwards. This will insert the character into the text at the position last typed.

To insert a full stop into the text press the '1' key once. To insert a space into the text press the '0' key once.

Note*

Please refer to your Nokia 6600 user guide should you encounter any problems with using the telephone.

The T9 input language

The Nokia 6600 uses the T9 text input language. This language allows you to reduce the number of keys you need to press to enter the text. This works well when you are using English as the language of preference; however should you choose to use Afrikaans it would be best to turn off the T9 input.

Turning off the T9 input language

The T9 input mode can be switched off at anytime when text must to be entered. When a text entry point is reached simple press the button indicated by the orange arrow (1) in figure 2. This will open a menu which have a menu entry 'Dictionary' on the first line. Move the joystick once to the right whilst the 'Dictionary' item is highlighted. Use the joystick to highlight the 'off' menu entry and press the joystick inwards a message indicating that the T9 input language have been turned off will appear briefly. This need only be done once. The same procedure can be followed to turn the T9 language back on again.

Using the T9 input language

The T9 greatly reduces the complexity of entering text data into a cell phone. When using the T9 language the characters are no longer entered one at a time, but rather words are formed based on the keys pressed.

The button with the desired letter need only be pressed once the T9 language will predict the word that you want. If the resultant word is not the correct word it can be changed by pressing the '*' key. Each time the '*' key is pressed another word will be predicted should the correct word be found the '0' key should be pressed to insert a space before the next word is entered. Should the word not be found in the list, the spell option may be selected by pressing the button indicated by the yellow arrow (4) in figure 2. The spell option will only become available when all the words in the list have been exhausted. Please refer to the section, using the keypad to enter text information, above for further information on how to enter text manually.

*Note**
Please refer to your Nokia 6600 user guide should you encounter any problems in using the telephone.

2.1.7 Entering numerical information

To enter numerical information into a text area: Press the key shown by the orange arrow (1) in figure 4. A sub menu will open with 'Number mode' on the second line. Use the joystick to select 'Number mode'. Only numbers will now be entered when any of the keys are pressed. To revert back to text, press the same key again then select the 'Alpha mode' option.

3. USING THE ETS DIETARY ASSISTANT

This section of the user guide explains how to use the Ets dietary assistant software installed on the Nokia 6600 cell phone. The Nokia 6600 has the ability to execute software applications developed specifically for the telephone by third party developers. These applications span a whole range different functionality from games to small programs with the ability to give you details about your stock portfolio. The Ets dietary assistant falls into this category. Its goal is to provide dietary information.

3.1 STARTING THE ETS DIETARY ASSISTANT

The ets dietary assistant will already be installed on your Nokia 6600. All that is needed to start using the ets dietary assistant is to select and run the assistant.

Figure 5

The Nokia 6600

To run the ets dietary assistant open the main menu of the Nokia 6600 cell phone. To open the main menu press the blue menu button, indicated in figure 5 by the blue arrow (1). The menu will open, and should look similar to the menu shown in figure 6 below.

Figure 6

The Nokia 6600 menu

Use the joystick, shown in figure 5 by the orange arrow (2), to navigate the main menu shown in figure 6. The ets dietary assistant should be the last item in the menu. Scroll down the menu until the ets dietary assistant logo is reached.

ets dietary assistant

Figure 7

The ets dietary assistant logo

The ets dietary assistant application may be started by pressing the joystick inwards. Please ensure the ets dietary assistant logo is highlighted before pressing the joystick. The main menu of the ets dietary assistant is shown below in figure 8.

Figure 8

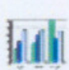
The ets dietary assistant main menu

Exiting the ets dietary assistant

To exit the ets dietary assistant press the selection key marked by the 'Exit' label. The program may also be closed by selecting the quit icon from the main menu.

3.2 USING THE ETS DIETARY ASSISTANT

The main menu of the ets dietary assistant consists of the following seven items:

-  Logbook.
-  Food
-  Exercise
-  Totals
-  Regular meals
-  Setup

-  Quit

In the following sections (3.2.1 – 3.2.9) these items are discussed in detail.

3.2.1 Interfacing with the ets dietary assistant

The input control or interfacing with the ets dietary assistant forms the basis for the user to manipulate the ets dietary assistant . The joystick and the two selection keys are used to control and navigate the ets dietary assistant .

Figure 9

The ets dietary assistant main menu.

The main menu of the ets dietary assistant is made up of the nine icons shown in figure 9. Each of the icons represents an action that can be taken by the . The menu is navigated using the joystick. The current selected option is shown as a blue icon with a description of the option. To execute a selected option press the joystick inwards.

3.2.2 Discussion: Logbook

The logbook keeps a record of all the data entered into the . All the meals and exercise information are stored in the logbook. The 'Logbook' option allows the user to view the contents of the logbook for that specific day. The time of the entry, description and ets value of the entry is shown. To open the 'Logbook' use the joystick to navigate the main menu. When the 'Logbook' icon turns blue it indicates that the 'Logbook' option is selected. Press the joystick inwards to open the option.

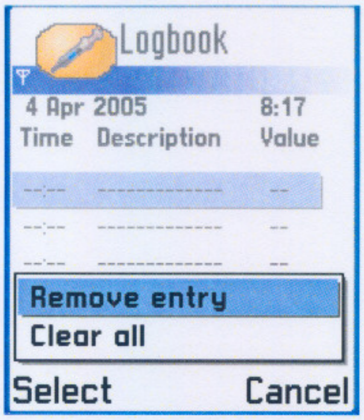


Figure 10

Logbook options

There are two options available through the selection keys. The first is the options menu. Under the options menu you'll find the options to *Clear all* the entries **(extreme caution should be used before using this function as the entire contents of the logbook will be erased)** and to remove an single entry: *Remove entry*. The items in the options menu can be accessed by using the joystick to scroll through the options. The second selection key can be used to go back to the previous menu, the main menu.

3.2.3 Discussion: Food

The second option in the main menu 'Food' is used to enter food items into the logbook. The 'Food' function can be used to add single food items one at a time.

Food Food

Figure 11

The food option

Use the joystick to highlight the 'Food' option, select this option by pressing down on the joystick. The option can also be selected by using the selection key marked with the 'Select' label. All the items in the different menus can be selected by using the joystick, scroll to the required item and press down on the joystick to select it. The selection key marked with the select/accept label can also be used to select the item. To go back to the previous menu press the selection key marked with the 'Back' label. There are a number of steps to complete when adding a new food entry to the list. The steps are listed below for easy reference.

- Select the 'Food' option.
- Enter the time of the meal. The time can be set by moving the joystick up or down. To select either hours or minutes move the joystick to the left or to the right. When the correct time is set use the selection button marked with the 'Accept' label to accept the set time.
- The food category menu is presented. Select the category that represents the foodstuff to add to the logbook from this list. Scroll to the required category using the joystick and select the item. The first item in the list is the 'Search for food...' item. Please refer to the section 'Using the search engine' for guidance on how to use this option.
- The food sub category menu is presented. Select the sub category that represents the foodstuff to add to the logbook from this list. Scroll to the required sub category using the joystick and select the item.
- The food menu is presented. Select the foodstuff to add to the logbook from this list. Scroll to the required food item using the joystick and select the item.
- The final menu requests the user to provide an indication as to the amount of the foodstuff that is consumed. The joystick is used to increase or decrease the amount by moving it up or down. The amount of ets contained in the foodstuff is also displayed on this screen. When the amount is set press the selection button with the 'Accept' label.

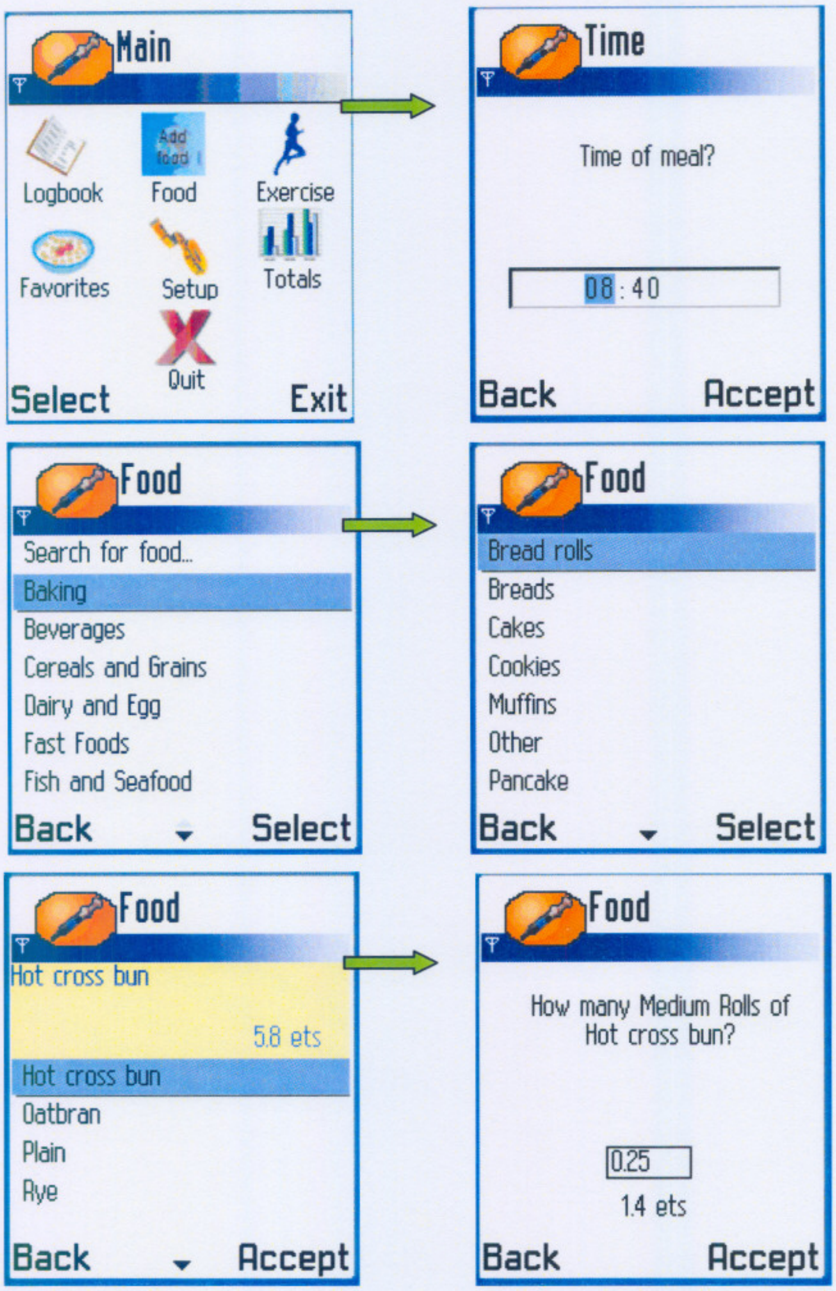


Figure 12

An illustration of the steps to follow to add a food item

By following the steps above a single food item has been added to the logbook. The main menu of the ets dietary assistant is presented again.

Using the search engine

Please read through section 3.2.3 to gain an understanding on how the items are added to the logbook before attempting to use the search engine.

To speed up the entry of a single food item a search engine is provided. The search engine can be found as the first entry in the food category menu. Select the 'Add food' item from the main menu to access the food category menu. Select the 'Search for food…' item at the top of the list.

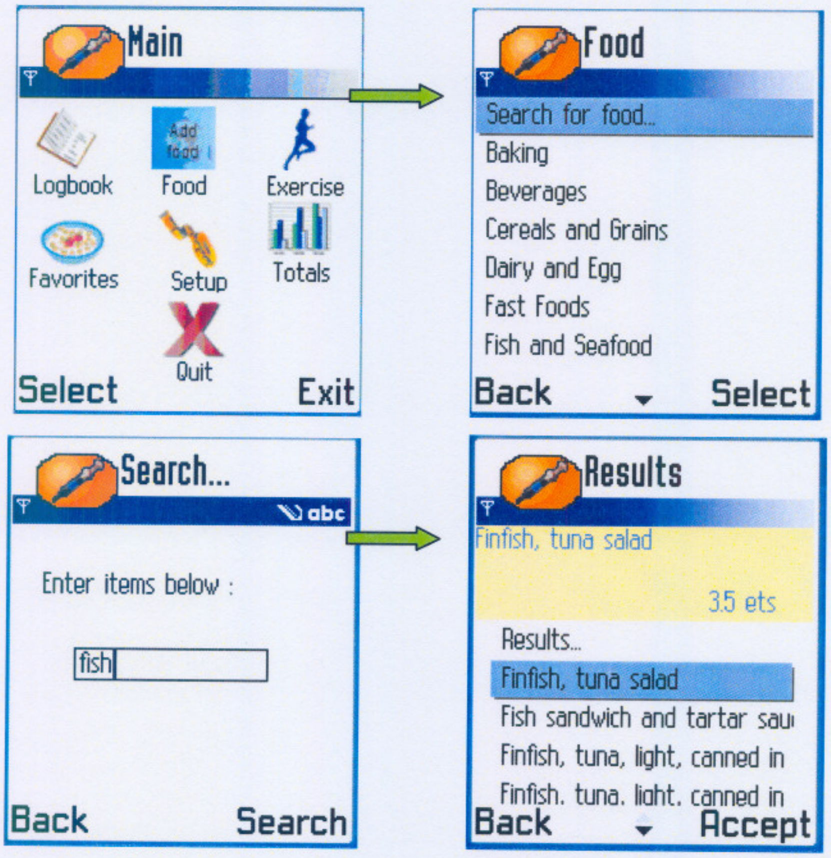


Figure 13

The steps to follow when using the search engine

Enter a description of the foodstuff to search for (example 'fish') and press the selection key with the search label. (Please refer to section 2.1.5 'Entering text information' for more details on how to enter text information). The results are displayed in a list. All the available food items that contain the item searched for are displayed. The joystick can be used to scroll through the list and to select the appropriate item.

3.2.4 Discussion: Exercise

After exercise the add exercise option can be used to add the specific exercise to the logbook. The steps to add exercises to the logbook are listed below:

- To add exercises to the logbook go to the third option in the main menu 'Exercise'.
- Enter the time of the exercise. The time can be set by moving the joystick up or down. To select either hours or minutes move the joystick to the left or to the right. When the correct time is set use the selection key marked with the 'Accept' label to accept the set time.
- The exercise menu is presented. Select the exercise to add to the logbook from this list. Scroll to the required exercise item using the joystick and select the item.

- The final menu requests the user to provide an indication as to the amount of the exercise done. The joystick is used to increase or decrease the amount by moving it up or down. The amount of ets that the exercise used up is also displayed on this screen. When the amount is set press the selection button with the 'Accept' label.

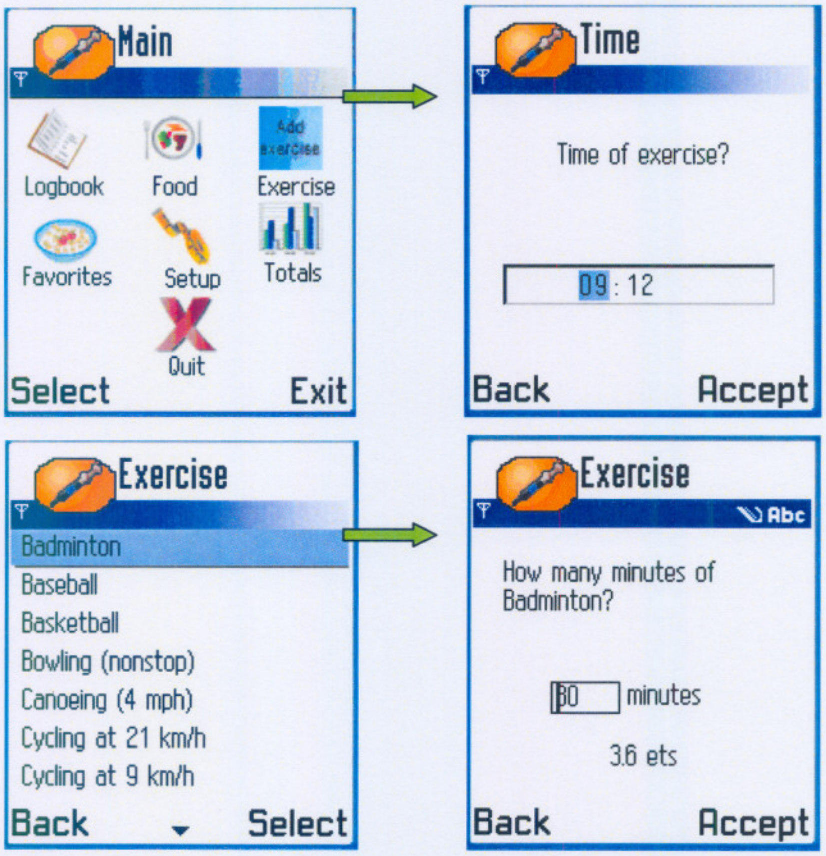


Figure 14

The steps to follow to add exercise

By following the steps above a single exercise item has been added to the logbook. The main menu of the ets dietary assistant is presented again.

3.2.5 Discussion: Totals

The 'Totals' option is the sixth item in the main menu list. Select the item by using the joystick. The nutritional totals for the day will be shown (ets, carbohydrates, protein, fat, kilojoules and kilocalories). Press the selection key with the 'Next' label to proceed.

The nutritional content left for the day will be shown (ets, etsCal and kilojoules). These totals will give an indication of how much of the days' recommended daily allowance is still available. Press the selection key with the 'Next' label to proceed.

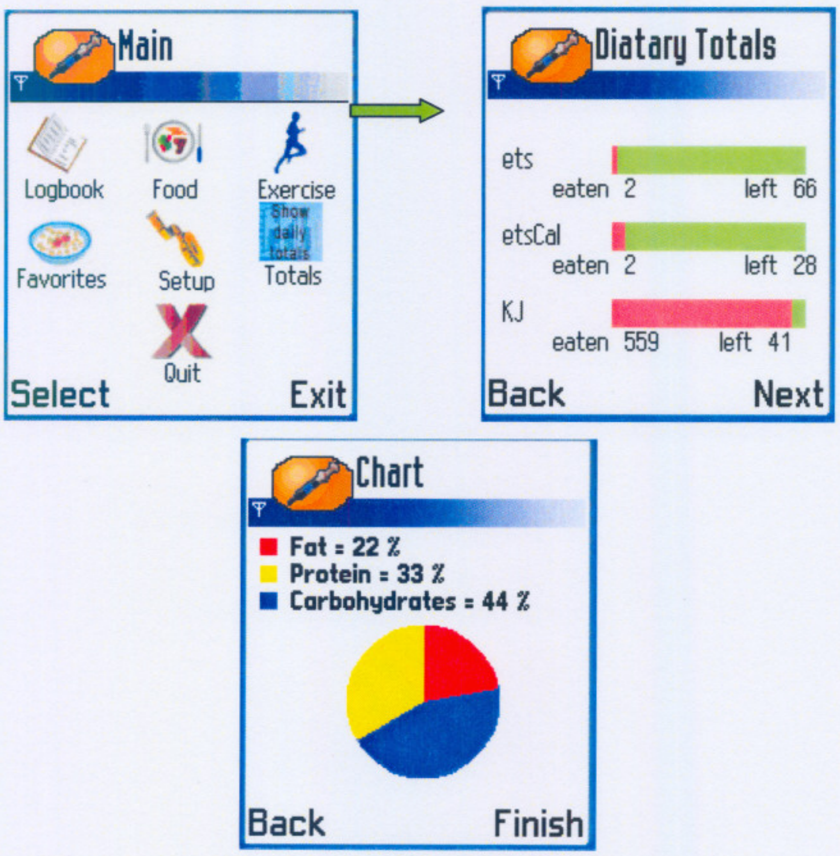


Figure 15

The daily totals

The final display in the 'Daily totals section' shows a pie chart with the percentages of fat, protein and carbohydrates contained in the food eaten for the day. Press the selection key with the 'Finish' label to proceed to the main menu of the ets dietary assistant .

3.2.6 Discussion: Favourites

Meals that are repeated often may be added to this list which will reduce the time and complexity of adding each item of a regular meal to the logbook.

The 'Favourites' option is the seventh item in the main menu list. Select the item by using the joystick.

Add a new meal

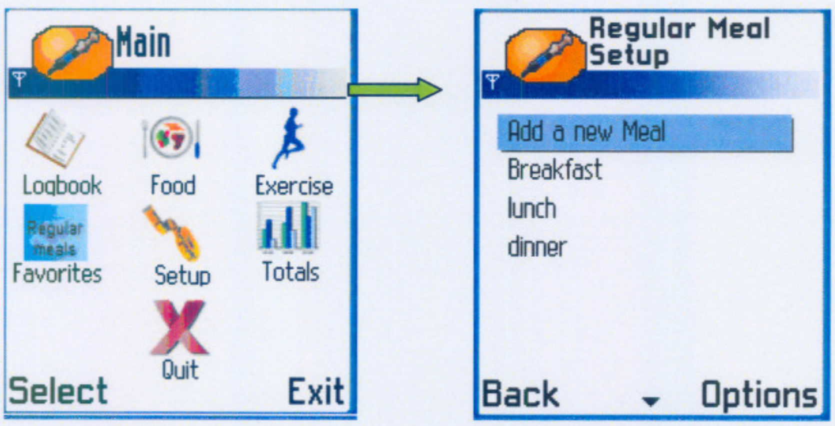
All the 'Favourites' must be defined first. This process requires that each meal be built up by selecting the items from the food menu.

To add a new meal make sure the 'Add a new meal' item is highlighted. Press the selection key with the 'Options' label. Select the 'Accept' entry in the 'Options' sub menu, this can be done by either pressing down on the joystick or by pressing the selection key marked with the select label.
The 'Add a new meal' option may also be executed by pressing the joystick inwards. This is the faster and easier option to use.

The next screen will ask for a unique name for the new meal to be entered into the regular meals record. Please type a unique and descriptive name for example: Breakfast or Midday snack. Please refer to section 2.1.5 (Entering text information) if you have any trouble entering a description for the meal. When the description of the meal is entered correctly press the selection key with the 'Accept' label or press the joystick inwards.

The food category menu is presented. Please refer to section 3.2.3 (Add food) for more information on how to add food. The procedure to follow here is very similar. There are only three differences.

- The 'Food' option from the main menu should not be selected. The 'Favourites' option was selected to get to this point.
- There will be no request to supply a time of meal for any of the entries. A regular meal is being constructed now and no entries will be made into the logbook yet, only when entries are made into the logbook will a time request be made. These meals are constructed for future reference.
- After an item is added to the meal the menu will return to the food category menu for the next food item to be added to the meal. After all the items that makes up the meal have been added to the meal record the selection key with the 'Done' label must be pressed to save the meal and exit to the main menu.



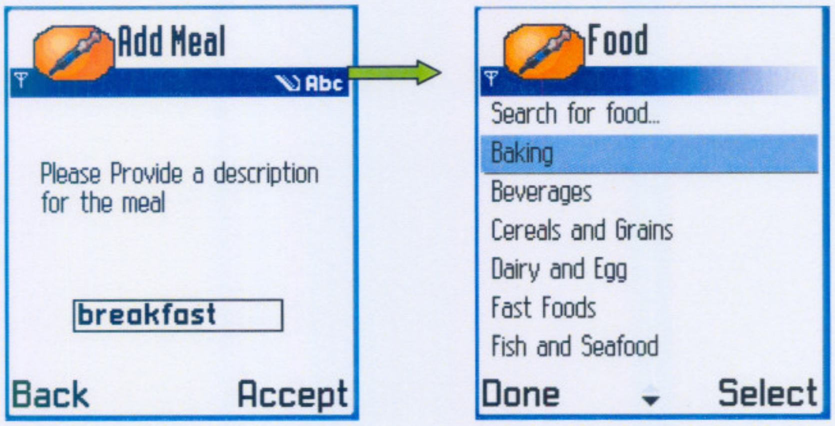


Figure 16

The add new meal procedure

Any number of different regular meals can be created for later easy reference. A list with six different regular meals may look like the list in figure 17 below.

Figure 17

A list of regular meals

Removing a meal from the regular meals list

Entries in the regular meals list can be removed should the meal no longer be needed or if a mistake was made when entering the details of the meal. Select the 'Regular meals' option in the main menu of the ets dietary assistant . The regular meals list will appear. Use the joystick to scroll to the required meal. With the meal highlighted press the selection key marked with the 'Options' label. Select the 'Delete' option from the options sub menu. The meal is permanently removed from the list.

Entering a regular meal into the logbook

After eating a meal that corresponds to one of the meals specified in the regular meals section it is convenient to add all the items eaten during that meal in one step.

Select the 'Favourites' option from the main menu. The display will look similar to the one shown in figure 17. Use the joystick to select the specific meal from the list of available meals defined previously. To select a meal press the selection key marked with the 'Options' label. Use the joystick to select the 'Accept' entry in the 'Options' sub menu, either press down the joystick or press the selection key marked with the select label. A list of all the items that make up the meal will be displayed, please verify that the items are correct and press the selection key marked with the 'Accept' label, or to go back to the regular meals menu press the selection key marked with the 'Back' label. Enter the time of the regular meal. The time can be set by moving the joystick up or down. To select either hours or minutes move the joystick to the left or to the right. When the correct time is set use the selection key marked with the 'Accept' label to accept the set time. A message will verify that the meal has been added to the logbook, press the selection key marked with the 'continue' label to precede to the main menu.

The complete meal will now be written to the logbook and no further action needs to be taken.

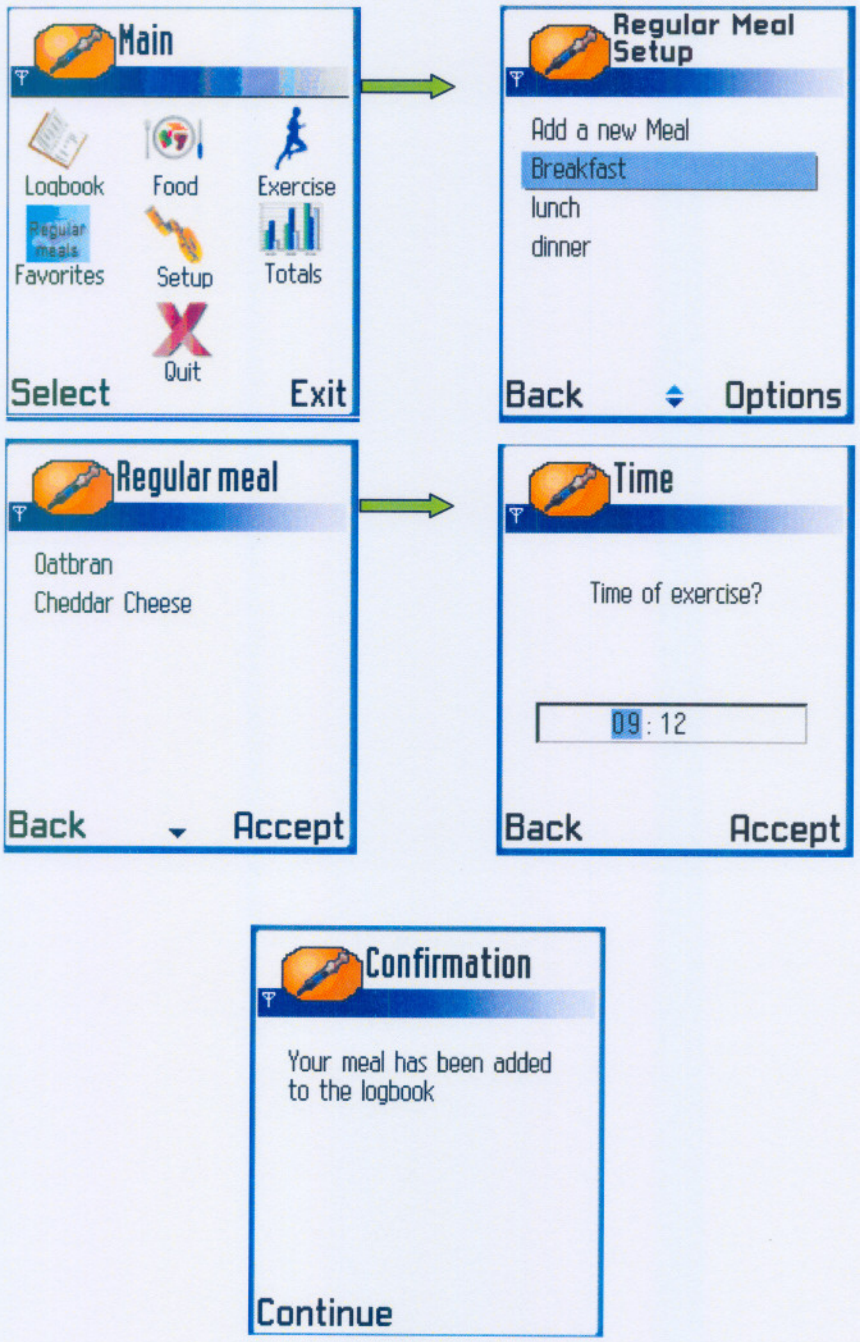


Figure 18

The steps the add a meal to the logbook

3.2.7 Discussion: Setup

The final item in the main menu is the 'SETUP' option.

Figure 19

Setup screen 1 of 4

In figure 19 above the first of the setup screen can be seen. Your weight, height and activity level is used to compute the recommended daily allowance (RDA) values for your diet.

Use the joystick to move between the different elements on the screen. To adjust the values for the weight and height press the joystick to the right to increase the value and left to decrease the value. Press the next button to proceed to the next screen.

Figure 20

Setup screen 2 of 4

The second setup screen is shown in figure 20. This screen requires information about your gender. Press the next button to proceed to the next screen.

Figure 21

Setup screen 3 of 4

The third setup screen is shown in figure 21. This screen requires information about your age. Use the joystick to adjust the value, press the joystick right the increase the value and left to decrease the value. Press the next button to proceed to the next screen.

Figure 22

Setup screen 4 of 4

The sixth setup screen is shown in figure 22. This screen requires information about your RDA. Suggested values for your RDA are provided in the red font next to the respective value boxes. The values may be adjusted selecting the appropriate value by using the joystick. Move the joystick to the right or to the left to increase or decrease the values.

To select the Kcal or KJ values : Move the cursor to the final value box on the display. Press the joystick inwards once. The Kcal and KJ options will turn darker and the values in the boxes will turn light grey. Move the joystick left or right to select either Kcal of KJ.

To go back to the value boxes: press the joystick inwards. The Kcal and KJ option will turn light grey and the values in the value boxes will turn darker. The cursor will blink in the bottom value box.