UNDERSTANDING GLYCAEMIC INDEX FOR A HEALTHY LIFE

Professor Sivapathasuntharam Mageswaran

Memorial Lecture – 2003

25.07.2003

Professor Vasanthy Arasaratnam
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Introduction

Late Prof.S.Mageswaran is one of the most dedicated and dynamic pioneers who played a major role in the development of the University particularly the Department of Chemistry and Faculty of Science.

Prof. Mageswaran is one of the best organic chemists. He served both in University of Peradeniya and University of Jaffna. His students and well wishers have established a fund for conducting a Memorial Lecture annually to honour him.

I am happy to see Prof. Vasanthy Arasaratnam, Dean, Faculty of Medicine and a Professor of Biochemistry of University of Jaffna delivering this Prof.S.Mageswaran Memorial Lecture – 2003. Prof.Arasaratnam has done research extensively in Biochemistry.

I wish Prof.V.Arasaratnam every success.

Prof.S.Mohanadas
Vice Chancellor
University of Jaffna
8th July 2003

UNDERSTANDING GLYCAEMIC INDEX FOR A HEALTHY LIFE

Ladies and Gentlemen,

It gives me great pleasure to present the Prof. S. Mageswaran Memorial Lecture, 2003. Even though I am not a student of late Prof. S. Mageswaran, I know that he was considered as an academician with principles and have dedicated his life to this University. I heard from my friends, how he worked to plan and build the present "Mageswaran Block". It is sad that we could not have his full services to this University.

Today, I wish to present an interesting phenomenon, which we could have experienced and heard from our ancestors in different forms but rather a new concept in the Nutrition world! The **Glycaemic Index.**

1. WHAT IS GLYCAEMIC INDEX?

Glycaemic Index (GI) measures the rate at which the carbohydrate in certain foods is digested and absorbed into the blood stream as glucose, i.e. the GI of a food represents its blood-glucose raising potential[1-5].

The Glycaemic Index according to FAO/WHO is defined as the incremental area under the blood glucose response curve of a 50g carbohydrate portion of a test food expressed as a percent of the response to the same amount of carbohydrate from a standard food taken by the same subject [1-6].

During digestion. all carbohydrates are broken down in the intestine into their simplest form, sugars, which then enter the blood. As blood glucose level rises, the normal response of the body is to increase the level of the hormone insulin in the bloodstream. Insulin, which is released by the pancreas, helps glucose to enter the cells. This, in turn, helps to bring down blood glucose level to normal. The blood sugar level is maintained by insulin when the blood sugar level is elevated and by glucagon when level is decreased. It is important to keep blood glucose levels stable. The body is usually very good at keeping this system going, unless a person has diabetes and his insulin either does not work well or they do not produce enough.

Foods with a high glycaemic index raise blood glucose quickly, (e.g. glucose) while with low glycaemic index (e.g. legumes) promote a slower release of glucose (and raise blood glucose slowly) and insulin. Diets with high-glycaemic index have been linked to an increased risk for both diabetes and heart disease[7-8].

2. WHAT DOES GLYCAEMIC INDEX OFFER?

The Glycemic Index

- reflects the physiological effect of foods,
- helps to keep blood glucose levels even,
- substitutes the old terms of complex and simple carbohydrates[10].

Glycemic Index (GI) ranks foods on a scale from 0 – 100, according to their actual effect on blood glucose levels[10]. On the Glycaemic Index scale, glucose is taken as 100 since it causes the greatest and most rapid rise in blood glucose - all other foods are rated in comparison to glucose[11]. Since the GI ranks foods based on their actual effect on blood glucose levels instead of on assumptions, it provides an accurate tool for regulating blood glucose levels. If a food has a glycaemic index of 75, it means that it raises blood glucose by 75% compared with glucose. Different studies of the same food have resulted in glycaemic variations ranging from 20-40 points.

Foods with an index number of 70 or more are considered to be of high GI, with an index number between 55-70 as medium GI, and 55 or less as low GI.

It has been proved that it is not the **amount** of carbohydrate, but rather **its rate of absorption and digestion** that determine the physiological response of the body[4]. It was previously thought that if same amount of carbohydrate is eaten (whatever that carbohydrate may be), it would have the same effect on the blood glucose levels. It is now known that the same amounts of different carbohydrate-containing foods have different effects on blood glucose levels. For instance, 30g of bread does not have the same GI as 30g of fruit or noodles.

3. LIST OF GI VALUES OF ALL FOODS

The GI of over 600 foods has been determined worldwide and new foods are being tested constantly. Table 1 gives the GI of different foods commonly consumed. Table 2 shows the foods classified based on low, medium and high GI values.

4. FACTORS THAT INFLUENCE THE GLYCAEMIC INDEX

The following factors influence the **digestion and absorption** of carbohydrates, and thus on blood-glucose levels, and hence affect the glycaemic index of the food[16]:

- the amount and type of sugar
- the type of carbohydrate
- the fat and protein content
- the method of food preparation and processing
- Others

Table 1: Carbohydrates with high (bad carbohydrates) and low glycaemic index (good carbohydrates)[12,13].

With high glycaemic index		With low glycaemic index	
Food substances	**GI**	**Food substances**	**GI**
Glucose	100	Wholemeal bread or bread with bran	50
Baked potatoes	95	Wholegrain rice	50
Very white bread	95	Peas	50
Mashed potatoes	90	Wholegrain cereals without sugar	50
Honey	90	Oat flakes	40
Cooked carrots	85	Fresh fruit juice (without sugar)	40
Cornflakes, Popcorn	85	Wholemeal rye bread	40
Sugar (sucrose)	75	Whole wheat pasta	40
White bread	70	Red kidney beans	40
Refined cereals with sugar	70	Dried peas	35
Chocolate bars	70	100% Stone ground wholemeal bread	35
Boiled potatoes	70	Milk products	35
Biscuits	70	Dried beans	30
Corn (maize)	70	Lentils	30
White rice	70	Chickpeas	30
Brown bread	65	100% Stone ground whole wheat pasta	30
Beetroot	65	Fresh fruit	30
Bananas	60	Fruit preserve (without sugar)	25
Jam	55	Dark chocolate (over 60% cocoa)	22
Non-whole wheat pasta	55	Fructose	20
		Soya	15

These apply regardless of whether it is liquid or solid, eaten on its own or in a meal, which contributes other nutrients such as fats and proteins.

Table 2: Glycaemic index of different foods commonly consumed[14,15].

LOW	MEDIUM	HIGH
50<	51-69	<70
	CEREALS	
Rice, Bran,	Untoasted muesli, white bread, hamburger bun, wholemeal bread.	Cornflakes, Puffed Wheat, Rice Bubbles, Breakfast bars.
	CRACKERS/CRISPBREADS/BISCUITS/CAKES	
Oatmeal, Rich tea biscuits, banana cake, pound cake, apple muffin.	Muesli bars with fruit, bran muffins.	Rice cakes, crackerbread, Morning Coffee, Donuts (cinnamon).
	GRAINS / PASTA	
Noodles, vermicelli, spaghetti, long grain white rice, bulgur, macaroni.	Macaroni cheese (packet).	Corn chips, Rice pasta.
	LEGUMES	
Soya beans, kidney beans, lentils, butter beans, chickpeas, lentils, baked beans, Bengal gram.	Green gram dahl, green pea soup.	Broad beans, lima beans, pinto beans.
	VEGETABLES	
Green peas, sweet corn, sweet potato, carrots.	New canned potatoes, new potatoes, beetroot.	French fries*, baked potatoes, pumpkin, parsnip, Pontiacs, Desiree, instant potato.

FRUITS		
Grapefruit, apples, pears, grapes, oranges.	Mango, papaw, bananas (just ripe), raisins, pineapple.	Watermelon, very ripe fruits.
DAIRY FOODS		
Whole milk, skim milk, chocolate milk, low fat flavoured yoghurt, low fat ice-cream, custard.	Ice cream (full fat).	
SUGARS		
Fructose (fruit sugar).	Lactose (milk sugar), Sucrose, honey.	Glucose, Glucodin, jellybeans, lifesavers, maltose.
BEVERAGES		
Apple juice, grapefruit juice, orange juice, Sustagen.	Cordial, Fanta.	Lucozade, Gatorade, Sports Plus.

4.1 THE AMOUNTS AND TYPES OF SUGARS

4.1.1 Types of sugars

Pure glucose has a maximum effect on blood glucose, i.e. has high GI e.g. glucose syrup (used in cake/confectionery manufacture), some sports drinks, and as 'dextrose' in many foods. Fructose occurs naturally in many fruits, some vegetables (corn, sweet potato), corn syrup, honey[17]. Fructose is absorbed as fructose and contributes very little to blood glucose levels because fructose must be converted into glucose by the liver. High fructose foods have a lower GI. And the greater the ratio of fructose (fruit sugar) to glucose in a food the lower its glycaemic index will be[18].

It is interesting to note that sugar (sucrose) has a lower index than bread or potatoes because sucrose is a disaccharide made up of both glucose and fructose,[19] if glucose has a glycaemic index of 100 and fructose is 23 then sucrose will be the average of these two figures i.e.: **100 (GI glucose) + 23 (GI fructose) = 61.5 (quoted as 65) / 2**

Lactose and sucrose have an intermediate effect on blood glucose levels. Honey has an intermediate GI (58).

4.1.2 Degree of ripeness

A ripe fruit or vegetable has a higher sugar content than one that is still green because during ripening large poly-saccharides are converted into small poly-saccharides (sugars) leading to a decrease in the time to digest (with some 40%) and, therefore, has a higher glycaemic index, e.g. the riper the food the higher the GI, e.g. yellow/black bananas vs. greenish bananas.

4.2 TYPE OF CARBOHYDRATES

It has been noticed for a long time that two carbohydrates (or poly- saccharides) with the same molecular weight but a different structure cause different reactions when digested.

4.2.1 The Chemical composition of the starch

If there is more of the branched starch (amylopectin) and less of the unbranched chains (amylose), digestion will be

quicker[20]. Amylose is made up of long straight chains of glucose molecules which tend to line up in rows and form compact clumps that are harder to gelatinise and therefore more difficult to digest (lower GI). Starches, such as rice, can have different types of starch structures, which affect their digestibility. Among the rice available in Sri Lanka BW 400 red varieties showed lowest GI of 27.5 and BW 2726-B (parboiled) showed the highest value of 42.9[21]. Some types of rice such as Basmati have higher amylose content. Other rice, with higher amylopectin content, is much easier to digest and has a higher GI. Beans and pulses have mostly amylose and are digested slowly. The starch in potatoes, for example, is digested and absorbed into the bloodstream relatively quickly.

4.2.2 Fibers

Fibers are "those carbohydrates that are not digested by human enzymes in the small intestine". Fibers shield the carbohydrates in food from immediate digestion, so the sugars in fiber-rich foods tend to be absorbed into the bloodstream more slowly. Soluble fiber slows down the digestion of starches and the absorption of glucose into the bloodstream, e.g. fruit pectin (especially cold climate fruits) and legume fiber (baked beans, lentils etc.)[22]. Further the foods containing soluble fiber have a lowering effect on the GI because they delay gastric emptying.

Insoluble fiber such as that found in digestive bran has very little effect on the digestibility of the carbohydrate foods it is found in. But, in very large amounts, bran can lower the GI.

4.3 THE FAT AND PROTEIN CONTENT

Stomach is emptied slowly if the food contains high amounts of protein and fat. The higher the fat content of foods the slower its carbohydrates are converted to sugar and absorbed into the bloodstream. As they take longer to digest they have a lower GI. Fat also slows the absorption of a meal. However, it is not advisable to eat too much protein or fat. Protein tends to wear out the body's insulin; and fat has the effect of decreasing the effectiveness of insulin. Protein also overtaxes the kidneys and an over-consumption thereof can lead to osteoporosis, arthritis and gout.

4.4 THE METHODS OF FOOD PREPARATION AND PROCESSING

Milling, blending, mixing, mashing and refining foods raise the GI of that food. That is why it is recommended to limit beating, liquidizing or processing in recipes. One of the most important factors in increasing GI is the degree of processing of carbohydrates. In highly processed carbohydrates, the outer bran and inner germ layer are removed from the original kernel of grain, which causes bigger spikes in blood sugar levels than would occur with less-processed grains. Foods, which are more processed, digested quicker and have a higher GI, e.g. instant potato, refined cereals. Processing makes the starch faster to digest. Whole-grain foods tend to have a lower glycaemic index than their more highly processed counterparts.

4.4.1 Degree of starch gelatinsation

Gelatinisation of starch occurs when the starchy food is exposed to liquid and heat (i.e. cooking). Water binds with starch (e.g. flour) in the presence of heat and gelatinises the flour. The heat and water expand the hard compact starch granules (which make the raw starch difficult to digest) into swollen granules. Some granules even burst and free the starch molecules. **The less a starch is gelatinised, the slower it is digested and absorbed.** In other words, it will have a **lower GI.**

Many confectionery items that contain sugar have a lower GI than those without! If sugar is added, the sugar binds with the liquid, preventing it from binding with the starch and thereby preventing gelatinisation.

4.4.2 Particle Size

Finely ground flour has a higher glycaemic index than more coarsely ground flour. Intact grains such as whole wheat, whole corn and whole rice have a much lower GI value than flours made from the same grains.

4.4.3 Degree of processing

The more processed/refined a food is, the higher the GI. Foods, which are more, textured, chewy, crunchy, fibrous tend to take longer to be digested and release their glucose into the blood stream more slowly than soft, refined or pre-cooked foods. Long grain white rice has a lower GI than quick cooking brown rice and

multigrain bread has a lower GI than whole meal bread[21].

4.4.4 Cooking method

Cooking methods such as frying, boiling and baking, all affect GI rating. The method of baking bread appears to influence its GI; traditional slow rising bread dough can have a lower GI than breads made with rapid-rise dough.

4.4.5 Boiling time

Briefly boiled rice, 1 minute, may result in twice the time to digest as compared to 6 minutes boiled rice.

4.5 OTHERS

4.5.1 Anti nutrients

Phytates, lectins and polyphenols (tannins) normally slow digestion and thereby decrease the GI.

4.5.2 Acidity

If an acidic food is added to a meal, this will lower the GI, e.g. by adding dressing to a salad, digestion of food by the stomach is made more slow. The higher the acid contents of a food, the slower its carbohydrates are converted to sugar and absorbed into the bloodstream. The more acidic a food, the lower is the GI of that food, e.g. lemon juice on vegetables, vinaigrette dressings on salad, pickled foods, increasing the acidity of bread by using sour dough fermentation. For example, a green apple will have a lower GI than a yellow Golden Delicious Apple[24].

4.5.3 Speed of eating

Studies have shown that blood-glucose levels rise less rapidly when eating more slowly. Food that has not been properly chewed also has a lower GI – it may also lead to indigestion.

4.5.4 Salt

Salt and salty foods/condiments tend to speed the rate of digestion of starches and increase the rate of absorption of glucose and increases the GI of the meal.

The Glycaemic Index of a food depends on many factors including harvest time, gene species, age of food, type of processing, nutritional profile, and many other variables. New potatoes have lower GI than desire potatoes and long grain rice lower GI than short grain rice.

4.6 COMBINATION OF FOODS IN MIXED MEALS

Often the GI of a given food is not what one would expect, e.g, the GI of brown bread is 70 whereas sweetened, low-fat fruit yoghurt is only 33. For this reason, all foods containing carbohydrate need to be tested to determine their GI. Eating proteins rich food in a meal lowers the overall GI of the meal. Rice with meat sauce has a lower GI than rice with tomato sauce[25].

5. GLYCAEMIC INDEX VERSUS GLYCAEMIC LOAD

The theory goes that if foods with low GI are eaten, the blood sugar levels will remain more stable. But when low glycaemic index foods are chosen and eaten too many of them at once, that is, if a meal with a high glycaemic load is eaten, the blood sugar will still rise dramatically and excessive amounts of insulin is required to deal with it. The blood sugar levels will not be nearly stable enough because the insulin index of the meal is too high[26,27]. The Insulin Index is a relatively new concept, which measures the amount of insulin the body produces in response to a set carbohydrate load in a particular food[28,29].

Which is more important, is glycaemic index or glycaemic load?

The glycaemic load of a meal has a much greater effect on its insulin index than its glycaemic index, so the total amounts of carbohydrates that are consumed control blood sugar levels[30,31]. If high glycaemic indexed carbohydrate foods are chosen, and if small amount of them is eaten, the blood sugar will be under control. Thus eating a small amount of carbohydrates with high GI is not unhealthy. While, too much of carbohydrates with low GI are still bad. Carrots have very high GI. But, a small amount of carrot eaten with other foods will not significantly elevate insulin levels. If a meal consisting of a pound of carrots is eaten, the insulin levels will be elevated.

Sucrose is a good example of the difference between glycaemic response and insulin response. Sugar (sucrose) is insulinogenic (meaning it elevates insulin), but the insulin-stimulation caused by ingesting sugar is greater than its GI would indicate. When dietary fat is added to sugar, lipoprotein lipase (LPL) is stimulated because chylomicron (triacylglycerols) are secreted into the blood in large quantities. In other words, the combination of fat and sucrose produces a mild glycaemic response, but with a powerful fat-storing insulin response[32].

Foods with similar or identical calories do not stimulate fat-storage equally. As an example, table sugar (sucrose) has the same caloric value as maltitol. When 30 grams of maltitol is given to fasting humans, there is only a slight response in serum glucose and insulin. After sucrose is ingested (in the same group) increases in these parameters are significant. Sucrose stimulates LPL activity in adipose tissue, while maltitol does not. Lower adipose tissue LPL activity results in lower body fat accumulation.

Though low GI foods do not stimulate fat-storage as efficiently as high GI foods, they still contain calories. If a person continuously eats food with 4,000 kcal per day and with low or high GI and do not exercise, then he will become over weight.

To effectively control the blood sugar levels it is important to eat both suitable types and amounts of

carbohydrates. Therefore it is necessary to eat meals with a low GI and a low glycaemic load. Only then the need for insulin can be reduced, and can reap the health benefits that we are striving for. Choosing foods with a low GI and low insulin index can improve diabetic management and may possibly reduce the incidence of diabetes complications e.g. heart disease, renal disease[33,34].

6. WHAT IS THE SIGNIFICANCE OF GLYCEMIC INDEX?

- Low GI means a smaller rise in blood sugar and can help to control established diabetes[35,36]
- Low GI diets can help people to lose weight and lower blood lipids[37-39]
- Low GI diets can improve the body's sensitivity to insulin
- High GI foods can help to re-fuel carbohydrate stores after exercise[40].

6.1 ADVANTAGES OF LOW GI FOODS

Low GI foods

- are best for most people, most of the time because they reduce the risk of disease
- are the most satiating (hunger satisfying), reduce appetite and help reduce overeating[41]
- help people with diabetes to control their blood sugar levels.
- help to reduce blood insulin levels and so reduce the undesirable effects of insulin resistance (e.g. coronary heart disease, obesity and type 2 diabetes.)

The GI tells us which foods make us store fat and which don't. Low-GI diets offer a unique set of benefits. They

- do not stimulate fat storage
- enhance sports performance
- improve energy levels while reducing sugar-related energy and mood swings
- improve muscle to fat ratio
- enhance mental alertness
- **may help to lower blood lipids**

6.2 DISDVANTAGES OF HIGH GI FOODS

A negative aspect of high GI foods and drinks is their ability to activate the fat enzyme, lipoprotein lipase. Foods and drinks, which are high in GI, encourage fat-storage and foods and drinks, which are of low in GI, do not. High-fat foods are not heart-healthy and they stimulate LPL, the fat-storing enzyme[42].

7. HOW TO USE THE GLYCAEMIC INDEX?

Look at foods that were eaten currently. Then work out ways to replace high GI foods with low GI alternatives, but it should be noted that the amounts (grams) of carbohydrate must be kept the same. The total amount of carbohydrate, the amount and type of fat, and the fiber and salt content of food are also very important. Why? Because foods high in fat often have a low GI. However, a high fat diet is not recommended for overweight people or people with diabetes[43].

Ten simple ways to change to a low GI diet

- The best way is to include one low GI food at each meal.
- Switch to breakfast cereals based on wheat and rice with bran (such as porridge).
- Eat grainy breads made with whole seeds, barley and oats. instead of white or brown bread.
- Eat long-grain rice in place of short-grained rice, but watch serving size.
- Use fat-reduced milk and low-fat yoghurt.
- Eat pulses and legumes (such as beans, lentils and peas).
- Eat legumes and green leafy vegetables in preference to other starchy vegetables.
- Favour apples, grapefruit, grapes, orange, pears, and under-ripe bananas in preference to other fruits.
- Favour less processed foods and foods that aren't over cooked, as processing and cooking makes food easier to digest.
- Eat fibre because it helps slow the digestion and absorption of carbohydrates.

Choose most vegetables without even thinking about their GI. Most are so low in carbohydrate, and they have no measurable effect on our blood sugar levels. Of the

higher GI containing vegetables like potato, sweet potato and corn: sweet potato and corn are the GI choices. Carrots, peas, beetroot and pumpkin in a normal size serving suit a low GI diet.

Essentially, low GI eating means a move back to the high carbohydrate foods that are staples in many parts of the world with an emphasis on whole foods such as the whole grains and legumes or pulses.

8 WHAT PROBLEMS ARE THERE IN PRACTICING GI?

1. GI values of all foods are not known.
2. Foods are not eaten as varied meals.
3. The GI varies for different brands of the same product
4. The GI does not relate to the nutritional value of a food. GI is a useful tool to people to know about the importance of carbohydrate and may help people who want to:

    1. lose weight or manage their weight better
    2. aid control of blood glucose levels (i.e. diabetics)
    3. to improve sporting performance in practical terms. It is more important to encourage people to increase their intake of carbohydrate from a wide variety of foods in addition to reducing their fat and salt intake and increasing their intake of fibre.

9. PRACTICAL IMPLICATIONS OF GLYCAEMIC INDEX WHICH CAN WORK FOR YOU!

9.1 LOW-GI FOODS

All foods with a GI of 50 or less are slow releasers of carbohydrates and are the best choices for inactive people, the overweight, sportsmen one[37] or two hours before exercise[44], as well as diabetics, hypoglycaemics, persons with high triacylglycerols[45] and Attention Deficit hyperactivity Disorder (ADD). Slow release carbohydrates do not result in a sudden and high rise in blood-glucose levels and therefore keep blood-glucose levels even for hours and do not cause the release of as much insulin as high-GI foods do. Therefore, low-GI foods also prevent the huge drop in blood-glucose, which occurs after the initial rapid rise in blood-glucose levels, which usually happens after eating high-GI foods.

9.2 INTERMEDIATE-GI FOODS

Intermediate GI foods are those with a GI of between 50 and 70. They are the best choice after low-intensity exercise of short duration, in the morning after exercising the previous night and directly after moderate activity in diabetics.

9.3 HIGH-GI FOODS

Foods with a GI of 70 and higher are called high-GI foods[46,47]. High-GI foods are excellent for the

prevention of fatigue and hypoglycaemia in regular sportsmen after doing moderate to high-intensity exercise. High-GI foods should, however, be limited by diabetics under normal circumstances, but are completely safe after strenuous exercise lasting two to three hours[48].

High GI foods elicit a huge insulin response, the body's way of coping with the sudden, sharp rise in blood-glucose. Often this insulin response is too much and blood-glucose levels then rapidly fall to below the starting point, a condition known as hypoglycaemia.

11. SPORT HEALTH AND GLYCAEMIC INDEX

Energy is mainly available from either fat or carbohydrate and it depends on an individual's state of rest or activity as to where the energy originates. Carbohydrate is the energy source for muscle glycogen and blood glucose[40,47]. During rest and low intensity exercise, the body is fuelled almost entirely aerobically and energy is mainly derived from release of free fatty acids. As exercise increases, there is a shift in fuel usage from fat to muscle glycogen and at 70 - 75% of maximal oxygen uptakes, nearly all energy is derived from muscle glycogen, with only a small proportion from blood glucose and free fatty acids[40,49]. Within ½ to 1 hour at this intensity, muscle glycogen is nearly depleted and the rate of depletion decreases as fitness level increases. At moderate to low work intensities, muscle glycogen levels can still be 50 - 60% of initial values after 1 - 3 hours exercise. As exercising continues muscle glycogen

stores become progressively lower until high intensity exercise cannot be maintained[40].

11.1 CARBOHYDRATE LOADING

High carbohydrate diet is a must for optimum sports performance, "carbo-loading" because it produces the biggest stores of muscle glycogen (the storage form of glucose)[47]. Carbohydrate loading is a technique used to store extra glycogen in the muscles before competition. This aids endurance athletes, as the extra glycogen stored allows them to continue at their maximum aerobic pace for a longer period of time. This method is of benefit in events over 90–120 minutes where glycogen depletion is of concern[47,50]. Carbohydrate loading is not recommended for events less than 90 minutes, as the extra glycogen is not required. Excess glycogen and water stored may increase body weight by one to two kilograms and can cause muscle stiffness[47].
The bigger the stores of glycogen and glucose, the longer one can go before fatigue sets in. Unlike the fat stores in the body, the carbohydrate stores are small. They are fully depleted after two to three hours of strenuous exercise. This drying up of carbohydrate stores is often called "hitting the wall". At this stage, the blood glucose concentration begins to decline, which may lead to symptoms such as confusion and even unconsciousness.

10.2 GI AND SPORTS PERFORMANCE

There are times when low GI foods provide an advantage and times when high GI foods are better. For best performance, a serious athlete needs to learn which foods

have high and low GI factors and when to eat them. It is one in which the athlete is undertaking a very strenuous form of exercise for longer than 90 minutes, during events like running, a marathon[51].

10.2.1 Before an event

Low GI foods are best before an event - approximately two hours before the big race, allowing time for the food to leave the stomach and reach the small intestine. Nausea and stomach cramps can be experienced if food is consumed too close to the race, e.g. less than an hour beforehand. The slow rate of carbohydrate digestion in low GI foods helps to ensure that a steady stream of glucose is released into the bloodstream during the event. The extra glucose is then available when needed towards the end of the exercise, when muscle carbohydrate stores are running low. Some low GI foods such as legumes are high in fiber and may cause gastrointestinal discomfort. However, not all low GI foods have high fiber content - rice and white pasta are good examples of low GI foods that don't contain much fiber[52].

Consume 1g of Carbohydrate for every Kg of body weight 1-2 hours before the start of the event.

10.2.2 During an event

During a competition, many athletes supplement their carbohydrate stores by consuming sugars in one form or another - sports drinks, bananas, etc. These foods provide extra glucose for the exercising muscles when they need it most. It is a well-known fact that

carbohydrate consumption during strenuous exercise extends endurance for a lot longer than otherwise possible. High GI foods should be used during long-lasting events. This form of carbohydrate is rapidly released into the bloodstream.

Liquid foods are usually tolerated well than solid foods while racing because they are emptied more quickly from the stomach. Sports drinks are ideal during the race because they replace water and electrolytes are also a good option during a race. Aim for 30g of Carbohydrate and 500ml of water per hour[48]. Look for commercial sports drinks with a high glucose - rather than fructose - content. Sucrose, which is a combination of glucose and fructose, is also preferable to pure fructose. It is possible to prepare cheap and very effective sports drink simply by combining five tablespoons of table sugar (sucrose) and 1/3 teaspoon of salt with a quart of water[52].

10.2.3 After an event

It is important to replenish glycogen stores in the muscle as soon as possible after the race. And this is where high GI foods can help, since they are digested and absorbed much faster and stimulates the hormone insulin, the hormone responsible for getting glucose into the muscle in the form of glycogen. Complete replenishment of glycogen stores post exercise may take between 24 - 48 hours. The rate of glycogen synthesis is most rapid immediately following termination of exercise and glycogen replenishment is much slower if carbohydrate intake is delayed for 2 hours[40]. So a concerted effort should be made to get as many high G.I foods in as soon as

possible[48]. However, recent research suggests that carbohydrate with a high GI may be more effective at stimulating glycogen synthesis than carbohydrate with a low GI. Carbohydrate intake at 15 minutes intervals may help to promote rapid muscle glycogen repletion due to maintaining an elevated insulin level. In the immediate post exercise period, the blood flow to the muscles is much greater and the muscle cell is more likely to take up glucose[40].

Athletes therefore should consume carbohydrates immediately after exercise. Delaying carbohydrate intake for too long will reduce muscle glycogen storage and impair recovery. Most athletes are not hungry after exercising and consumption of a high carbohydrate drink has the dual benefit of quenching thirst and replenishing muscle glycogen[40,52].

10.2.3.1 To maximize Glycogen replenishment after competition[48]

- Consuming 100gm carbohydrate within 15-30 minutes of exercise to maximise repletion of muscle glycogen stores[48]. This is equivalent to approximately 500ml of Recovery Drink. Aim to consume 1 - 1.5g of Carbohydrate per Kg of body weight each 2 hours after exercise
- Ingest carbohydrate soon after the event and maintain a high carbohydrate intake for the next 24 hours.

- Consume 10g of Carbohydrate per Kg of body weight over the 24 hours following prolonged exercise.
- Choose high GI foods in the replenishment phase
- Alcohol delays glycogen re-synthesis, so avoid it. It can also lower blood glucose levels.
- The primary goal is to make sure to eat and drink carbohydrate soon after the exercise session.
- Eating a low GI breakfast will maintain higher blood sugar until lunchtime.

10.2.3.2 SUGGESTED LOADING PROGRAMME

- Six to four days before competition, a low carbohydrate diet (40–50%) is followed while exercising to deplete the body's glycogen stores
- Three to one days before competition a high carbohydrate diet (70–80%) is followed while decreasing exercise to super-saturate the body's glycogen stores.
- Consume at least three to four liters of water on carbohydrate loading days as 2.7g of water is stored with every gram of glycogen
- Immediately after exercise on Day Three consume 200g of carbohydrates, then consume 50–100g of complex carbohydrates every hour afterwards (up to 10g of carbohydrate per kilogram body weight)
- On Days One and Two consume a diet of 70–80% carbohydrates
- On the day before competition switch to low fiber foods and sports carbohydrate drinks to lower residue

in the gastro-intestinal tract. This helps to prevent feeling full or heavy during competition

- Day of competition drink
  - 250 ml of glucose polymer carbohydrate every 15 minutes from four hours to one hour before event.
  - 500 ml again 30 minutes before event.

Note:

This suggested carbohydrate loading program can be very physically demanding and should be used only about two to three times a year for more important events. For less important and shorter events the depletion phase may be deleted and the athlete may just follow the high carbohydrate diet for days three to one before the competition, while gradually tapering training volume to increase glycogen stores.

All athletes should ensure that they have a high intake of carbohydrates as it is easy in hard training to become **glycogen depleted** which will decrease endurance and exercise performance. An athlete in heavy training should consume 500-600g of carbohydrates each day. This is much higher than the typical adult who eats only 240g a day on average.

Glycogen depletion and loading will only occur in the muscles exercised. Therefore exercise activity should be the same as that which is to be carried out during competition.

For training heavily, or training more than once a day, make sure to ingest plenty of high-GI foods, especially during the two hours after a workout.

If a person does not train more than once a day and if the workouts usually last for less than 60 minutes, he can probably store adequate leg-muscle glycogen between workouts by relying on low GI.

To maintain blood glucose levels through the night, low GI foods should be chosen at dinner. Similar slow acting foods are preferable at the meal prior to a sporting event, whereas faster acting high GI food or drink would be best during the event[40,52].

10.3 SPORT INDUCED HYPOGLYCEMIA

This occurs when a person does not eat low GI food before exercise and either eats nothing after exercise or eat low GI foods after exercise. In order to prevent this, one should take low GI carbohydrates about one hour before exercise, Intermediate GI carbohydrate during and within the first 30-60 minutes after exercise if he is diabetic (high GI if non-diabetic). By doing this one will perform and feel a lot better[53].

11. OBESITY AND USE OF GLYCAEMIC INDEX ON WEIGHT LOSS

11.1 OBESITY

Excess weight leads to at least 300,000 deaths per year[21,54-56]. Obesity now accounts for more deaths and

chronic disorders, and poorer health-related quality of life, than either smoking or problem drinking[57]. Obesity/overweight can lead to early death, having, or dying from, a heart attack, stroke, or other types of cardiovascular diseases[58-60], developing diabetes[61], developing cancer of the colon, kidney, breast, or endometrium, having arthritis, developing gallstones, being infertile, developing asthma as an adult, snoring or suffering from sleep apnea, or developing cataracts[62,63].

What Causes Weight Gain?

Weight changes depends on a simple rule:

Weight change = Calories in - Calories out

If the calories consumed in each day is burnt, there's nothing left over for storage in fat cells and weight remains the same. If the food eaten is more than what is burnt, this leads to addition of fat and hence to an increase in weight.

11.2 FACTORS INFLUENCING WEIGHT CHANGE

11.2.1 Genes

Some people are genetically predisposed to gain weight more easily than others or to store fat around the abdomen and chest. It's also possible that humans have a genetic drive to eat more than they need for the present in order to store energy for future. This is called the

thrifty gene hypothesis[64]. It suggests that eating extra food whenever possible helped early humans survive feast-or-famine conditions. If such thrifty genes still exist, they aren't doing us much good in an environment in which food is constantly available[46].

11.2.2 Diet

At the risk of stating the obvious, the quantity and composition of food has a strong impact on weight.

11.2.3 Physical activity

More calories are burnt by an active person, which means that less energy will be available for storage as fat. Exercising more also reduces the chances of developing heart disease, some types of cancer, and other chronic diseases[65,66]. In other words, physical activity is a key element of weight control and health[67].

Emerging evidence suggests that a more balanced approach that includes protein, carbohydrates, and fats has value as a weight-loss strategy. Another increasingly common approach to weight loss is eating more protein and less carbohydrate. This may help to drop some killos. Limiting carbohydrates can help to avoid sharp spikes in blood sugar and insulin levels, and equally sharp declines in blood sugar. Keeping blood sugar at a relatively steady level may dampen the appetite. However, many high-protein, low carbohydrate diets are full of saturated and trans fats. These could significantly increase the risk of heart disease regardless of any actual

weight loss[16,68-71]. A restrictive high-protein, low-carbohydrate diet may also limit the consumption of important vitamins, minerals, and other nutrients found in banned carbohydrates such as fruits, vegetables, and whole grains.

11.2.4 Lessons from Losers

What is the secret of weight loss?[72-77]

Exercise

Burn an average of 400 calories per day in physical activity. That's the equivalent of about an hour of brisk walking.

Eat fewer calories

Consume about 1,400 calories a day. This does not mean, however, that a person should aim for 1,400 calories a day. What is right for an individual is based on the weight, height, and activity leve[78].

Switch to lower-fat diets

Do not be afraid of good fats. Good fats such as mono and polyunsaturated fatty acids can help to improve the blood cholesterol level when the saturated or trans fats or highly processed carbohydrates are replaced.

Tame the blood sugar and Eat low GI foods

Another aspect of weight loss, is to keep blood glucose levels as even as possible. High-GI diets promote faster weight gain, higher body fat levels[42] higher adipocyte volume, and hypertriglyceridemia[79]. Slimming diet containing only low GI carbohydrates lost weight compared with a diet containing only high GI carbohydrates. The success of the low GI slimming diet was attributed to the fact that a low GI diet does not cause a major insulin response, resulting in lower insulin levels and more even blood glucose levels. By avoiding high GI carbohydrates, except after exercise, and consuming the prudent diet that should be 50-60% CHO, 25-30% fat and 12-20% protein, and eating mostly low GI carbohydrates, body fat loss is optimised. Lower GI foods will help to burn more of the body fat partly because they will encourage eating less[80,81]. On the other hand high GI carbohydrates usually cause a reactive hypoglycaemia, and thus one is inclined to eat sooner due to low blood glucose. Cut back on sugars and sweets, and eat more fruits and vegetables[78].

Drink water

When thirsty, reach for water. Drinking juice or sugared soda can give several hundred calories a day without even realizing it.

11.3 CAN YOU BE TOO THIN?

It is certainly possible to be dangerously thin. Individuals with eating disorders such as anorexia nervosa and bulimia--and those with wasting diseases such as cancer, AIDS, and heart failure--can lose so much weight that they do not have enough energy or basic building blocks to keep themselves alive. What about people who are thin but do not have an eating disorder? Weighing too much--or too little-- isn't as healthy as some middleweight. The main problem with this idea is that most of these studies included smokers and individuals with early but as-yet undetected chronic and fatal diseases. Low weights don't necessarily cause early death. Instead, low weight is often the result of illnesses or habits that may be fatal[62,63].

12. GLYCAEMIC INDEX AND DISEASES

12.1 DIABETES

Diabetes mellitus (mellitus means honey) is not caused by eating sugar. In untreated diabetes, glucose does not pass from the blood to the cells and builds up to high levels in the blood, which may result in further complications.

There are two major types of diabetes mellitus: insulin-dependent (type 1) and non-insulin dependent (type 2). The first usually occurs in children and adults under 30; people over 40 generally develop the second type.

12.1.1 Glycaemic index and diabetes: Handle with care

In all diabetes, it is important to eat enough food to supply energy but not so much that the body converts the excess to fat. Diabetics should try to lose excess body fat with a healthy diet and exercise[83]. For many years, the accepted dietary dogma for diabetes was to avoid sugary foods (the so-called simple carbohydrates) because they were absorbed quickly by the body and produced a more rapid and larger rise in blood glucose[84]. Complex carbohydrates (or starches) were encouraged because it was believed they were more slowly absorbed, resulting in a smaller rise in blood glucose levels. After a closer look at the scientific evidence, the American Diabetes Association concluded in their 1994 Nutrition Recommendations' that the most Important factor is the total amount of carbohydrate consumed rather than the source[19,85,86].

According to GI research, the glycaemic index of a food remains the same whether 1g or 1kg of it is consumed because the numbers are a relative ranking comparing one food with another. In theory, one can eat less of a high GI food and more of a low GI food and end up with the same blood glucose response. The glycaemic load should also be considered[87,88]. In other words, portion size still counts[19,89].

In general, low fat foods with a low glycaemic index are best for people with diabetes. Sugar should be restricted to a lower level than most normal people eat, but small amounts can be used. Now it is being recommended

plenty of fruits, vegetables and high-fibre carbohydrate foods with limited intake of potatoes, concentrated sugar, white rice, white bread[90] and moderate amounts of protein foods, dairy products (low-fat for adults) and less of foods high in saturated fat. The best fats are mono-unsaturated or small amounts of polyunsaturated fats[91]. All fats should be used sparingly. A low fat diet, in combination with good glycaemic control, can help to avoid the development of these difficult management problems[92].

If a diabetic person on a healthy diet for diabetes includes one or more low GI foods in each meal, the blood glucose levels will improve. Clinical studies in individuals with diabetes have shown that low GI diets improve glucose leading to a decrease in HbA1c[91,93], fructosamine, postprandial blood glucose excursions, the incidence of hypoglycaemia, and blood lipids. A number of epidemiological studies have shown that intake of high glycaemic index foods is positively associated with an increased risk of type 2 diabetes[91].

Now there is evidence that a low glycaemic index diet leads to improvements in total fat mass, lipid profile, lower postprandial glucose and insulin levels.

12.1.2 How can the Glycaemic Index help people with diabetes?[43,94,95]

Improvement in glycaemic control can be achieved with relatively painless changes to the diet, e.g. one type of rice, fruit or bread with a low GI can be chosen instead

of similar but higher value GI foods[96-101] i.e. Substitute half of the daily carbohydrate intake with low GI foods instead of high GI foods[38]. For people with type 2 diabetes, the slower effect of the low GI foods gives their own insulin more time to act. This evens out blood glucose levels[7].

- There is evidence that a low GI diet can help control established diabetes, help people to lose weight (low GI foods as the longer digestion time means they have a higher satiety value) and lower blood lipids (fats), and improve the body's sensitivity to insulin by keeping blood glucose levels more stable than when high GI foods are consumed. Those who consumed diets high GI had 2-5 times the risk of developing diabetes than those who ate a diet rich in high fibre less processed cereals - even after controlling for known risk factors such as age and BMI[19,86,102,103].
- eat meals regularly and space them evenly through out the day
- have similar amounts of carbohydrate at each meal
- include some low fat, low GI foods daily[19]
- More variety in the diet is possible as foods previously thought sweet can be included, e.g. sweet potato, low fat ice cream or a teaspoon of sugar. Diabetes Australia advises that up to 40g of sugar (10 level teaspoons), spread throughout the day, can be included if the basic diet is low fat, low GI and high fibre[52].

- High-GI foods/drinks should not be consumed by hypoglycaemics or diabetics[104].
- To maintain blood glucose levels through the night, low GI foods should be chosen at dinner.
- Encourage clients who would like to try the glycemic index (GI) approach to measure blood glucose frequently (premeal and postmeal) to better determine how a food affects their blood glucose levels.

12.2 HYPOGLYCAEMIA (LOW BLOOD SUGAR)

12.2.1 Definition and Symptoms

Hypoglycemia is a condition in which the sugar level in the blood falls below normal levels (hypo=under and glycaemia=blood sugar/glucose). Many people suffer from hypoglycaemia today because of the freely available and consumed foods with high fat and a high GI value. The most common form of hypoglycemia occurs after a meal is eaten. This is called reactive hypoglycemia. High GI foods, except when eaten during, or after exercise, cause most people's blood glucose to surge upwards within a short period of time i.e. 30-60 minutes after ingestion. The human body then reacts, or overreacts in the case of a person suffering from hypoglycaemia, by releasing insulin to counteract the threat of sustained high blood glucose. This causes a rapid fall in blood glucose resulting in the typical stress-like symptoms of low blood sugar i.e. tremor, heart palpitations, sweating, anxiety, sleepiness, weakness and the very common feeling of chronic fatigue.

Hypoglycemia can also affect mental function and lead to restlessness. irritability, poor concentration. lethargy and drowsiness.

12.2.2 Treatment

The main aim of the treatment of hypoglycemia is to prevent sudden large increases in blood glucose levels. Eating low GI food when not exercising, or 1-2 hours before exercising, causes a steady release of glucose into the bloodstream, preventing an insulin surge (hyperinsulinemia).

12.2.3 How to prevent hypoglycemia than to try and cure it once present

Follow these simple guidelines to prevent hypoglycemia:

- Eat regular meals and snacks, preferably every three hours
- Include low GI carbohydrates at every meal or snack, since the blood glucose is sustained by carbohydrates and therefore the nutrient that gives us energy

Avoid eating high GI carbohydrates alone. Preferably avoid them altogether, but if they have to be consumed, always combine with low GI carbohydrates or at least some protein.

12.3 ATTENTION DEFICIT DISORDER (ADD)

For years it was believed that ADD was caused, or at least aggravated by the consumption of sugar. Sugar was believed to cause hypoglycaemia and it was found that hyperactivity and/or ADD and hypoglycaemia are interrelated. Now that we know that it is the high glycaemic index (GI) foods that cause the hypoglycaemia, (especially when eaten when inactive or before exercise or alone).

12.3.1 Why ADD and hypoglycaemia are interrelated

Many children with ADD crave high GI carbohydrates, which leads to hypoglycaemia. All high GI foods cause a rapid rise in blood glucose, which causes a temporary surge of energy and at the same time hyperactivity. Too much glucose is drawn out of the blood due to increased insulin secretion and the blood sugar level to fall below normal. The end result is a hypoglycaemic attack with irritability, poor sleeping habits and lack of concentration. When high GI foods are eaten for breakfast, the children can suffer a hypoglycaemic attack 1-1.5 hours later, which is still before first break and at a time when their brain should still be receiving a steady supply of energy from the food that was eaten 2-3 hours before. If these foods are eaten at 2-3h intervals, which often happen, since the person feels the need to compensate for the tired feeling by eating some more high GI foods, the same scenario can repeat itself later in the morning, which is the reason these children cannot

concentrate. The brain fuel is constantly undergoing huge swings and this is not conducive to thinking or behaving in a normal manner.

Caffeine can also cause hyperactivity initially and hypoglycaemia with the resultant symptoms later. This is due to the fact that caffeine also stimulates the adrenal glands to secrete adrenalin, which stimulates the liver to pour glucose into the blood stream. This sudden rise in blood sugar levels can once again cause the pancreas to pour out insulin. The end result is a hypoglycaemic attack.

12.3.2 Treatment of ADD

In the light of the above, all high GI foods, caffeine and any food to which a child with ADD is allergic, should be avoided. Children with ADD should rather avoid high GI foods such as refined bread, most cereals, cold drinks, energy drinks and sweets that are high in glucose, rather than to just avoid foods that are high in sugar. If low GI foods are eaten most of the time, but especially for breakfast, since the latter sets the tone for the rest of the day, the brain receives a steady supply of energy from the food. It keeps blood glucose levels even and enables the child to concentrate better. The emotions also become more stable.

12.4 CORONARY HEART DISEASES

12.4.1 CORONARY HEART DISEASE (CHD)

CHD is the number one killer in many countries. The development of CHD is a slow process and starts with fatty deposit build up on the inner walls of the arteries of the heart and brain. This may lead to narrowing of the arteries (artherosclerosis) that supply the heart and the brain with oxygen. When the blood cannot get through anymore due to a, the person suffers a heart attack or stroke. Often a part of the heart muscle dies or one section of the body is paralyzed (stroke). Here the excess cholesterol slowly constricts and clogs the arteries, the individual do not suffer any discomfort or pain, except maybe for fatigue and shortness of breath. Some people experience chest pain (angina), but for many the first warning sign could be a heart attack or stroke.

Cholesterol-carrying lipoproteins play a central role in the development of atherosclerotic plaque and cardiovascular diseases. The two main types, (LDL, HDL) basically work in opposite directions. Low-density lipoproteins (LDL) carry cholesterol from the liver to the rest of the body. When there is too much LDL cholesterol in the blood, it can be deposited on the walls of the coronary arteries and hence LDL cholesterol is often referred to as the "bad" cholesterol. High-density lipoproteins (HDL) carry cholesterol from the tissues back to the liver, which processes the cholesterol for elimination from the body. HDL makes it less likely

that excess cholesterol in the blood will be deposited in the coronary arteries. which is why HDL cholesterol is often referred to as the "good" cholesterol[103].

When you have your cholesterol checked, the results will indicate your total blood cholesterol level. If you fasted overnight before giving a blood sample, the test results should also include separate counts for your HDL and LDL. In general, the higher your LDL and the lower your HDL, the greater your risk for atherosclerosis and heart disease.

For adults age 20 years or over, the most recent federal guidelines--from the National Cholesterol Education Program--recommend the following target levels:

- Total cholesterol less than 200mg/dl
- HDL cholesterol levels greater than 40mg/dl
- LDL cholesterol levels less than 100mg/dl[87]

12.4.2 Risk factors

A number of risk factors contribute to an increased risk of CHD. These are high blood cholesterol, high blood pressure, being overweight, diabetes, smoking, stress, a lack of exercise and a family history of CHD.

12.4.3 Dietary advice

"Eat a low-fat, low-cholesterol diet." Most of us have heard this simple recommendation so often. Unfortunately, this simple message now seems largely out of date. Foods that are low in total fat, saturated fat,

GI and sodium will not cause fatty deposits to build up on the inner walls of the arteries[105,106]. A number of epidemiological studies have shown that intake of high glycaemic index foods is positively associated with an increased risk of coronary heart disease[19]. Increased intake of fibers decreases the risk of CHD[107].

13. CRITICISMS OF THE GI

Critics of the glycaemic index point out that the complexity of the GI concept may make it very difficult to apply in day-to-day dining situations[108]. For example, the pre-meal glucose concentration can affect the rate of gastric emptying, thus influencing the glycaemic response to a food. At high glucose concentrations (>170 mg/dl), gastric emptying is delayed; when blood glucose levels are low, a rapid gastric emptying rate occurs[108]. Other factors that affect the blood glucose response include stress, time of day, recent physical activity, health status, and length of time since the previous meal. Using glycaemic index information correctly requires much more nutrition survey than casually thumbing through a reference book and labelling foods good and bad on the basis of their GI value[19].

The GI approach has been dismissed by some in the mistaken belief that it does not work in "mixed meal" situations or when there is added fat or protein. In fact, at least a dozen studies show that the GI of single foods predicts the response to mixed meals. However the correlation coefficient (r) for the observed glycaemic response versus the predicted response was 0.88[25]. Thus

the lack of effect in mixed meals can be faulted on methodological grounds[48].

Unfortunately, some foods have been rated as "good" or "bad" simply on the basis of their GI. It is certainly not appropriate to substitute boiled potatoes (high GI) with potato crisps (lower GI). Large amounts of fat in a food reduce glycaemia by slowing down gastric emptying, but glucose tolerance to the subsequent meal is impaired. Thus, high-fat foods may be seen in a "falsely favourable" light if the GI is the only criterion for selection. The total amount of carbohydrate, the amount and type of fat, and the fibre, micronutrient, and salt contents of a food are also important considerations. The proper use of the GI is to compare foods within categories of similar nutrient profile[48].

The use of 50-g carbohydrate portion sizes in GI testing has been criticized because it does not reflect a normal serving size. However, it has been shown that the glucose response to 1000-kJ portions (a reasonable serving size) of a range of foods is highly correlated. Other criticisms of GI, including "too complex," "too many variables," a "burden" on people with diabetes, "restriction of food variety," and "too many foods with unknown GI values," stem from inexperience with this relatively new concept[109].

Another concern about the GI is that the insulin response to a food may be more relevant than the glycaemic response. However it has been found that, insulin responses in healthy people have followed the rank order

of the glycaemic responses[14,26]. High-protein and high-fat foods, however, stimulate greater insulin responses than predicted by the level of glycaemia[27]. More exaggerated insulin responses are seen when people with underlying insulin resistance consume high-GI foods[11]. However it has been found that insulin responses to 1000-kJ portions of common foods, ordinary soft breads (white or wholemeal) showed scores that were among the highest of any of the foods tested[27].

15. CONCLUSION

By using the GI concept diabetics, people who suffer from low blood sugar (hypoglycemia), children with Attention Deficit Disorder (ADD), and sportsmen may optimize their blood glucose control. By using the GI concept in combination with low-fat foods, both triglycerides and blood pressure may be lowered **and HDL-cholesterol (good cholesterol) may be increased.** For those wanting to lose weight, the increased satiety levels **and reduced insulin levels (a fat storer) resulting from following a low GI diet may enhance weight loss.** Even people who suffer from gout may benefit from following a low fat, low GI diet. More than 600 individual foods have been tested for their GI[12]. The GI concept has been widely adopted in diabetes management in Australia, New Zealand, Canada, the United Kingdom, and France[15,91]. The GI remains controversial in the United States, where it is perceived as too complex for health professionals as well as for ordinary people or simply not worth the trouble. Contrary to popular belief, low-GI foods are not the

same as foods based on high complex carbohydrate and fiber. nor are high GI foods those based on simple sugars[12]. This is because the starch is fully gelatinized and can be rapidly digested and absorbed[14].

The concept of the glycaemic index of foods is becoming quite well known. Soon the glycaemic index of tested foods will be shown on their labels. If people knew this they would realise that it is futile to consider the glycaemic index of a meal whilst ignoring its glycaemic load, because both affect our insulin levels.

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