

The impact of breakfast in metabolic and digestive health

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ABSTRACT

Aim: The purpose of this study is to explore whether the types and quality of breakfast could influence energy levels (blood glucose levels) and propose ideal breakfast models.

Background: It is widely considered that a regular breakfast provides a number of health benefits; however, there is no general scientific agreement regarding what kind of food should be consumed. Evidence supports the importance of balancing blood glucose levels by low glycaemic index/load (L-GI/L) and increased protein diets, in particular in metabolic disorders, which non-alcoholic fatty liver disease (NAFLD) has a close relation to.

Patients and methods: This study was conducted by using a valid and standard questionnaire at the University of Worcester to evaluate the breakfast and dietary habits and energy levels. The Kruskal-Wallis test was used for statistical analysis.

Results: No significant differences were found either between breakfast consumption, energy levels, types of snack and amount of caffeine intake in the morning or between types of breakfast, energy levels, types of snack, and amount of caffeine intake in the morning. However, potential differences in energy levels were found across the groups of breakfast types: glycaemia (GL) ($p=.057$) and protein intake ($p=.056$).

Conclusion: The types and quality of breakfast would be key as regular breakfast consumption alone did not show adequate health benefits. Lower GL foods and higher protein intake at breakfast were found to be associated with higher energy levels. It is therefore recommended that breakfast foods should be low in GL and high in protein. These changes may lead to better health status and prevention of disease, especially metabolic and liver disorders, in the long term.

Keywords: Food habits, Blood glucose, Glycaemic index, Diet therapy.

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Introduction

According to an old phrase, breakfast is considered the most important meal of the day, although it is the meal which is most often missed and the most underestimated (1, 2). This saying has recently acquired scientific support (3). The reported health benefits from regular breakfast consumption include a better nutritional profile (4), reduced body mass index (5), better cognitive

functions (6), reduced incidence of chronic degenerating diseases including type 2 diabetes and cardiovascular disease (7), a healthier lifestyle (8), healthier food choices (9), and regular eating and exercise patterns (1).

Despite a large number of studies supporting the importance of breakfast consumption, there is no general scientific agreement as to what kind of food should be consumed for breakfast (10), and few studies have investigated how the types and quality of breakfast influence the health benefits (11). When considering factors leading to the health benefits of breakfast consumption, it could

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be argued that the influence of types of food on blood glucose levels may be the most important point, since low and slow glucose release is believed to keep the energy levels balanced, preventing 'energy dips' as well as providing long satiety between meals (12). The beneficial effects of low glycaemic index/load (LGI/L) foods include improved glucose and lipid metabolism (13, 14), low GI/L foods can increase long-term satiety, reduce hunger and lower subsequent voluntary food intake (15, 16). Nilsson et al. (2008) (17) argue that LGI foods are capable of keeping blood glucose levels lower and stable during the course of a whole day, and thus this could be expected to further add to the beneficial effects of breakfast, providing an ideal 'nutritional start' in the morning.

Furthermore, a large amount of research supports the fact that imbalanced blood glucose levels are associated with chronic metabolic disorders. LGI/L diets were shown to reduce fasting and post-prandial insulin, glucose, triacylglycerol, total cholesterol, and non-esterified fatty acid concentrations, and thus this type of diet is considered to be associated with a wide range of benefits with respect to established metabolic risk factors (18-20). Fatty liver disease is now considered to be strongly associated with insulin resistance (21); it has been found to be highly correlated with all the components of metabolic syndrome (22). A concern for non-alcoholic liver disease (NAFLD) is growing in clinical hepatology (23); for example one in four or five American adults are considered to have NAFLD (24). Recent research discovered that high glycaemic index (HGI) foods were related to increased hepatic fat (25-27), and low glycaemic index (LGI)/L diet, emphasising on complex carbohydrates with fibres and moderately high protein intake (15-20%), has shown to be significantly effective in the treatment of the

patients with non-alcoholic steatohepatitis (NASH) (28).

However, caution should be exercised in food choices which are solely based on the GI/L, as the foods may be energy dense and contain substantial amount of sugars (sucrose), or undesirable fatty acids which contribute to the reduction of glycaemic response (29, 30). Furthermore, unlike the GL, the GI cannot be solemnly relied on, as the GI and amount of a food eaten are all used to determine the postprandial glycaemic response (30). Therefore, it would appear that the GL concept, which is based on how much carbohydrate there is in a serving (31), may be more straightforward when applied to the public.

Increased protein intake has also been discovered to be associated with improved glycaemic response, resulting in balanced energy levels (32, 33), and protein content in a meal is considered to be key for satiety and appetite regulation (34). Protein source has also been considered to be a determinant of satiating efficacy (35, 36). For example, several human studies found that whey protein increases satiety more than other types of protein, such as casein, soy, and egg albumin (35, 37, 38). This is considered to be due to its quick digestion and absorption which can result in rapid and larger increase in plasma amino acids (39), although this property was found to be associated with a negative effect, a faster release of insulin (40). Since hyperglycaemia and hyperinsulinaemia are both factors of insulin resistance, the insulinotropic component of milk products could be a cause of concern for health (41, 42).

Given the impact of glycaemic level in metabolic and digestive health, the overall aim of this study is to explore whether breakfast consumption and the types and quality of food eaten influence blood glucose levels (energy levels) later in the morning, and formulate recommendations on ideal breakfast models

developing from the findings of this empirical

pastries, 'Weetabix', shredded wheat, 'Cheerios',

Table 1. An overall summary of the participants

Categories	Summaries
Demographic	<ul style="list-style-type: none"> • Most of them are students of the age group of 18-24 years.
Breakfast	<ul style="list-style-type: none"> • The majority of the sample were categorised as 'regular breakfast eaters' and more than half of the sample had breakfast every single day. • The GL of breakfast was found to consist of: a MGL (45.2%), a LGL (36.9%), and a HGL (17.9%). • The majority of the sample had one portion of protein (59.5%), while quite a number of people ($n=21$, 25%) had zero portions of protein.
Weight	<ul style="list-style-type: none"> • Almost all participants were found to have an idea of a healthy weight. • The mean rankings were compared for three breakfast groups (regular- and non-regular breakfast eaters and complete breakfast skippers), the regular breakfast eaters had the highest ranking (3.91), regarding themselves as being within a healthy weight.
Energy levels	<ul style="list-style-type: none"> • The majority of the sample regarded their energy levels as 'okay' or more.
Snacking	<ul style="list-style-type: none"> • 86% of participants consumed snacks, and more than half of them snacked regularly, around twice daily. • A slightly higher number of people had HGL-snacks (53.2%) than LGL-snacks (46.8%).
Caffeine intake	<ul style="list-style-type: none"> • Most of the participants (89%) consumed caffeinated drinks, and about 40% of them drank caffeinated beverages 13 times or more per week.

work as well as the literature review.

Patients and Methods

The site of this study is the University of Worcester in United Kingdom, and from where a sample population of staff and students was selected. The sample size of this study consisted of a mixture of 93 males and females: 24 males and 69 females; of these 83 were students and the remaining were staff. Two people were withdrawn from the sample due to insufficient data collected. A self-completion structured questionnaire was chosen to extract the data, and this consisted of three parts: part one: demographic questions, part two: questions about breakfast habits and part three: questions about snacking and caffeine intake habits. An overall summary of the participants can be found in table 1.

The GL of breakfast was grouped into low-GL (such as oat porridge, 'All Bran', bran flakes, fruits (except bananas) and vegetables, wholemeal pita bread), medium-GL (MGL) (such as 'Special K', muesli, wholemeal bread,

bananas) and high-GL (such as white bread, cornflakes, 'Coco Pops', 'Nesquick'), and types of snack into LGL and HGL, according to the GL information (12, 43). The amount of caffeine consumption for each participant was calculated based on the published caffeine content information of each beverage (44, 45).

The Kruskal-Wallis test was used to determine whether there are significant differences among variables. Breakfast consumption habits (regular breakfast eaters, non-regular breakfast eaters, and complete breakfast skippers), the GL of breakfast (low, medium and high), and protein intake (none, one portion, two portions, and three portions) at breakfast were used as categorical independent variables, while energy levels (a 5-point scale), types of snacks (no intake, LGL, and HGL), and the amount of caffeine intake (mg) were used as dependent variables. In this study, statistical analyses were performed by the Statistical Package for the Social Science (SPSS) statistical software package version 14.0 for Windows (46).

Results

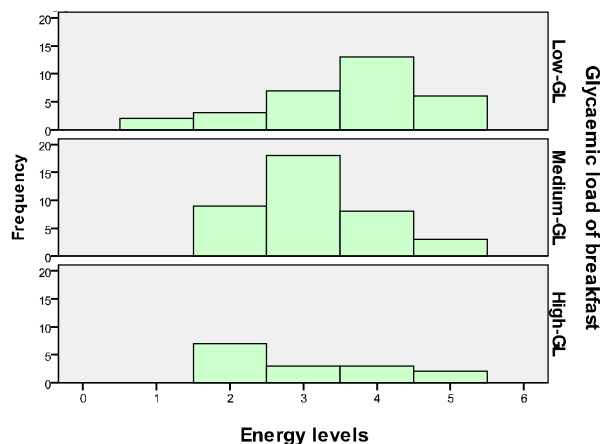
The associations between breakfast consumption and variables (energy levels, the GL of snacks consumed and the amount of caffeine intake)

The Kruskal-Willis test did not find statistically significant differences between breakfast consumption and all these variables at the 5% level (energy levels= $p=.55$, the GL of snacks= $p=.56$, and the amount of caffeine intake= $p=.50$).

The association between types (GL) of breakfast and variables

Energy levels

The Kruskal-Willis test found $p=.057$ (Gp1, $n=31$: LGL; Gp2, $n=38$: MGL; Gp3, $n=15$: HGL), $X^2(2, n=84)=5.72, p=.057$). This figure is very close to the significant level of $p<.05$, and thus this suggests that there is a potential difference in energy levels across the three GL groups, although it is not statistically significant enough (Fig. 1).



* 5-point scale (very low to very good)

Figure 1. The association between GL of breakfast and energy levels

Types (GL) of snack

Although the Kruskal-Willis test found $p=.33$ (Gp1, $n=31$: LGL; Gp2, $n=38$: MGL; Gp3, $n=15$: HGL), $X^2(2, n=84)=2.23, p=.33$, the mean ranks (median) show that both an LGL- and MGL-breakfast are the lowest overall

ranking, which corresponds to the lowest score of snack groups.

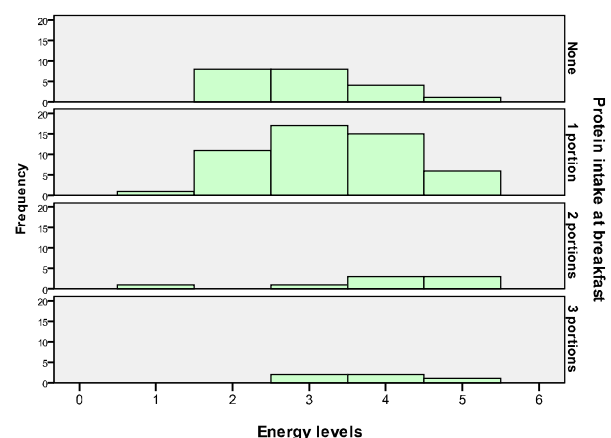
Caffeine intake

The Kruskal-Willis test did not find a statistically significant difference in the amount of caffeine intake across the three levels of GL breakfast (Gp1, $n=31$: LGL; Gp2, $n=38$: MGL; Gp3, $n=15$: HGL), $X^2(2, n=84)=3.78, p=.15$. However, the mean ranks show that low-GL has the lowest overall ranking which corresponds to the lowest amount of caffeine intake.

The association between protein intake at breakfast

Energy levels

The Kruskal-Willis test found $p=.056$ (Gp1, $n=21$: none; Gp2, $n=50$: 1 portion; Gp3, $n=8$: 2 portions; Gp4, $n=5$: 3 portions), $X^2(3, n=84)=7.56, p=.056$). This figure is very close to the significant level ($p<.05$), and thus this suggests that there is a potential difference in energy levels across the four groups of protein intake (Fig. 2). The mean ranks (median) show that both two and three portions of protein intake have the highest overall ranking (4.0) which corresponds to the highest score on energy levels.



* 5-point scale (very low to very good)

Figure 2. The association between protein intake at breakfast and energy levels

Types (GL) of snack

The Kruskal-Willis test did not find a statistically significant difference in GL levels of snacks across the four groups of protein intake (Gp1, $n=21$: none; Gp2, $n=50$: 1 portion; Gp3, $n=8$: 2 portions; Gp4, $n=5$: 3 portions), $X^2(3, n=84) = 1.95, p = .58$). However, the mean ranks show that protein intake at breakfast, including all three different portions, has the lower overall ranking, which corresponds to a lower GL of snacks than the non-protein intake group.

Amount of caffeine intake

The Kruskal-Willis test did not find a statistically significant difference in the amount of caffeine intake across the four groups of protein intake (Gp1, $n=21$: none; Gp2, $n=50$: 1 portion; Gp3, $n=8$: 2 portions; Gp4, $n=5$: 3 portions), $X^2(3, n=84) = .88, p = .83$). However, the mean ranks show that three portions of protein intake at breakfast have the lowest overall rank, which corresponds to the lowest amount of caffeine intake.

To conclude, all the results were not significant at the 5%, however, potential differences in energy levels were found across the groups of breakfast GL ($p = .057$) and protein intake at breakfast ($p = .056$). Moreover, trends were also observed in all other sets of associations.

Discussion

The empirical work in this study demonstrated that lower levels of glycaemic load and higher portions of protein intake at breakfast were associated with higher levels of energy, possibly by controlling blood glucose levels. The findings both from this present study and the literature review suggest that the concept of the LGL and increased protein intake are one of the most essential factors to be applied to breakfast, as well as any other meals of the day.

Marsh & Brand-Miller (2008) (47) are of the strong belief that using the GI is fairly easy for most people, as it simply means substituting one HGI food for one LGI food in the same food group, rather than making major dietary changes. The examples can be found in Table 2.

It could be summarised that, in order to adapt the benefits of the LGI/L, individuals should be advised to increase their consumption of fruit, vegetables and legumes, choose wholegrain products which have been minimally and traditionally processed, such as stone-ground, sourdough, or pumpernickel bread and old-fashioned oatmeal, and limit the intake of potatoes and sugar (48). These recommendations would tend to promote diets high in fibre, micronutrients and antioxidants and low in energy density (12, 47).

As for ideal amount of protein intake, a number of studies suggest that the dietary reference values (DRVs) (15% or 0.75g of protein per kg body weight per day (0.75g/kg/d)) are not adequate, particularly for older adults since a moderately higher protein intake of 1.0-1.3g/kg/d would be required to maintain nitrogen balance, as well as offset decreased protein synthetic efficiency and insulin action (49, 50). Diets with a moderately higher protein intake (20-35% of total energy) have not appeared to be associated with negative health outcomes (51, 52).

Furthermore, de Castro (2004) (53) argues that adults require a minimum of 15g of essential amino acids (AAs) or at least 30g of total protein at each meal to fully stimulate skeletal muscle protein synthesis, and Layman (2009) (54) supports this view. 30g of protein at breakfast appears to be appropriate and thus could be a target amount, as the recommendations above can result in about 90g of protein intake: 19% of daily intake results in 90g of intake if the person is a female aged between 19 and 50 years-old ($1900\text{kcal} \times 19\% \div 4\text{kcal} = 90.25\text{g}$).

Table 2. Using the glycaemic index/load is easy (12, 47).

HGL foods should be switched to	LGL foods
Bread – both white (HGL) and wholemeal (MGL)	<ul style="list-style-type: none"> • Sourdough / pumpernickel rye breads • Bread made from legume-based flours • Bread made from stone-ground flour is better
Processed breakfast cereals	<ul style="list-style-type: none"> • Unrefined cereals such as rolled oats or natural muesli with a small amount of dried fruit • LGI processed cereals such as those containing psyllium husk.
Plain biscuits or crackers	<ul style="list-style-type: none"> • Biscuits made with dried fruit, oats and wholegrain.
Cakes and muffins	<ul style="list-style-type: none"> • Cakes made with fruit, oats and wholegrain.
Potato	<ul style="list-style-type: none"> • Baby new potatoes, sweet potatoes, and yam. • Make mashed potatoes (50%) with cannellini beans (50%).
Rice – white short grain rice, such as jasmine rice	<ul style="list-style-type: none"> • Longer grain varieties such as basmati, moolgiri, doongara rice. • Brown rice and pearl barley.

Table 3. Good protein sources

Sources	Rationales (references)
Eggs	<ul style="list-style-type: none"> • A good source of protein, vitamin D/A/B2, and iodine (62) • Easy to access and prepare (62) • There is no recommended limit on how many eggs should be consumed; the amount of dietary cholesterol consumed was found to have less effect on cholesterol levels in the blood than that of saturated fats consumed (66) • A good source of tryptophan, which is required for serotonin synthesis. Serotonin is found to be associated with mood and cognitive function (67) • Boiled or poached eggs would be best, since these methods prevent the fats in the yolks from being oxidized before and during the cooking process (31)
Beans and pulses	<ul style="list-style-type: none"> • Low fat sources of protein, fibre, vitamins and minerals (62) • Can be counted as a portion of '5 a day' (62) • Cheap and easy to prepare (tinned and frozen legumes) (62) • A literature review states that the observed benefits of legume consumption includes reduced cancer risk, promoting CV health, weight management and blood sugar control (68) • Soya beans are the best protein source among legumes: dry soya beans contain about twice as much protein as other legumes (40%) (69) • A food labelling of health claims for soya protein to help reduce blood cholesterol levels has been approved by several countries, including the USA, the UK and Japan (70).
Nuts and seeds	<ul style="list-style-type: none"> • Linseeds, walnuts and pumpkin seeds are rich sources of n-3 PUFAs (31) • In addition to a favourable fatty acid profile and good protein sources, nuts and peanuts also contain cardioprotective nutrients, such as fibre and potassium, calcium, magnesium, and phytosterols (71), and were found to reduce total and LDL-cholesterol (72)
Fish	<ul style="list-style-type: none"> • Fish high in n-3 PUFAs include salmon, mackerel, sardines, and herrings (31) • The benefits of increased consumption of oily fish (EPA and DHA) to improve CV risk factors are widely accepted (73) • N-3 PUFAs may be potent anti-inflammatory agents (74)
Poultry	<ul style="list-style-type: none"> • Chicken without skin is a good source of low fat protein (31) • Similarly to eggs, poultry, turkey in particular, is also a good source of tryptophan (67)

Moreover, 1.3g/kg/d results in 91g of intake if a person with 70kg of body weight is considered (70x1.3=91g).

The literature review indicates that the choice of good protein foods would be difficult, due to

the potential health concerns of cow's milk. Melnik (2009) (55) also consider its containing active insulin-like growth factor (IGF) 1 and IGF-2 as another health concern because of an enormous impact on the human GH/insulin/IGF-1

axis, disturbing most sensitive hormonal regulatory signalling networks, which has an impact on most chronic diseases in Western societies. These include acne (56), atherosclerosis (57), diabetes (48), obesity (58), cancer (59) and neurodegenerative diseases (60). Furthermore, IGF1 has also been found to be associated with fibrosis and steatosis of non-alcoholic liver disease

legumes, nuts/seeds, fish and poultry. The addition of non-dairy protein powder, such as soy, pea and hemp protein, to foods could be useful to boost protein intake (64). The rationales of these choices can be found in Table 3. Table 4 suggests the ideal portion sizes of protein foods, targeting 30g (1.3g/kg/d) of protein, and suitable combinations with carbohydrate foods for breakfast.

Table 4. Examples of portion sizes and combinations of foods (43, 75)

Food groups	Suggestions
Eggs	<ul style="list-style-type: none"> • One big egg (P=6.3g) + one cup of soya milk (243g, P=7g) + walnuts 7 halves(P= 2.1g) = PTTL 15.4g + a slice of rye bread (P=2.72g) = PGTTL 18.12g
Legumes	<ul style="list-style-type: none"> • Green (fresh) soybeans cooked 120g (P=14.82g) or • Half a cup of red kidney beans (128g, P=6.75g) + a small portion of chicken breast (28g, P=8.7g) = PTTL 15.45g + 100g of cooked quinoa (P=4.4g) =PGTTL 19.89g
Nuts and seeds	<ul style="list-style-type: none"> • Walnuts 7 halves (14g, P=2.1g) + 10 almonds (10g, P=2g) + 10g of pumpkin seeds (P=2.5g) + one cup of soy milk (P=7g) = PTTL13.6g + a bowl of oat porridge (P=5.5g) = PGTTL19.1g *Wheat-based RTEC, such as All-bran, contains less (2.1g for 30g) than oats, and thus it is suggested that a dairy alternative to cow's milk should be increased or non-dairy protein powder, such as soy, pea and hemp protein, should be added.
Fish	<ul style="list-style-type: none"> • 70g of salmon fillet (P= 15.5g) or • 60g of tinned sardines (P=15g) or • 60g of tinned mackerel (P= 16g) + a slice of rye bread (2.72g of protein) = PTTL around 18g
Poultry	<ul style="list-style-type: none"> • Turkey 50g = 15g of protein or • Chicken breast 52g = 16.1g of protein + 100g of chickpeas (P=4.95g, 27g of carbohydrate) = PTTL around 20g

*P = protein, TTL = total, GTTL = ground total

(NALD) (61).

The problem is that milk and dairy products may be the most commonly consumed protein sources at breakfast due to easy access and the governments' recommendations, for example in the UK and the USA, in particular for its calcium content (55, 62). However, calcium can be obtained from other foods and more highly absorbed from beans and most greens (40-64%) than milk (32%), and calcium from the fortified products, such as cereals, juice and soy milk, can be absorbed nearly as well as dairy calcium (63).

Therefore, it could be argued that the recommended protein sources include eggs,

It could be concluded that choosing the right kinds of cereal (LGL) and milk, as well as increasing protein intake, would be key for energy (blood glucose) balancing, ideal breakfast, as these seem to constitute the breakfast menu consumed by the majority of people. In the long term, these changes may lead to better health status and prevention of disease, especially metabolic disorders, which may be linked to liver health. Finally, we strongly hope that healthier ready-to-eat cereals which are enriched with protein and extra fibre, as well as being made from wholegrain (preferably oats due to its LGL and nutrient-rich properties (65)) and containing less sugar, will be

available on the market in the near future. This is believed to promote improved health to the public.

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