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Breakfast and Adult's and Children's Behavior

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1. Introduction

The term breakfast is used in a number of ways. Studies provide varying definitions of breakfast including: eating after overnight fasting; the first meal of the day; eating before the start of daily activities; eating within two hours of waking; any food or beverage consumed between 05.00 and 09.00; eating before 10.00; and eating a meal in the morning that provides between 20-35 percent of daily energy needs. Some studies do not define breakfast at all other than investigating eating occasions that are described as breakfast by the participants. Given this variation in definition one might expect considerable variation in the observed effects. However, there is generally a good consensus about both health and behavioural effects of consuming breakfast and these are summarised here.

Epidemiological studies have identified a number of behaviours which influence health. Consumption of breakfast is often considered one of these important health-related behaviours (Berkman & Breslow, 1983) and there has been considerable research into its effects. There have been recent concerns that fewer people are now eating breakfast and this has been confirmed in nationally representative surveys (Haines et al., 1996; Kant and Graubard, 2006). For example, in the USA breakfast consumption among adults aged 20 to 74 years decreased from 86 percent in 1965 to 75 percent in 1991. It has also been found that breakfast consumption has declined in children, with the steepest drop being observed amongst adolescents aged 11 to 18 years (Siega-Riz, Popkin and Carson, 1998). This effect has been confirmed in data from the National Health and Nutrition Examination Surveys (NHANES) and results from the 2001-02 survey showed that children are less

likely to consume breakfast as they get older. For example, among children aged two to five years about 95 per cent eat breakfast. However, in the twelve to nineteen year age group less than seventy percent of the children ate breakfast.

The next sections summarise two areas which show why consumption of breakfast is so important.

1.1 Breakfast and nutritional recommendations

Regular breakfast consumption is associated with higher intake of key vitamins and minerals (Rampersaud et al., 2005; Ruxton and Kirk, 1997). This may increase the likelihood of meeting nutritional requirements. Conversely, breakfast skippers may not make up for missed nutrients at other meals (Morgan, Zabik and Stampley, 1986). Breakfasts containing ready-to-eat-cereal may also improve the diet due to fortification with micronutrients and low fat levels. Indeed, a review of breakfast and the diet of adults confirms that breakfast eaters consume better quality diets that include more fibre and nutrients and fewer calories than breakfast skippers (Timlin and Pereira, 2007).This has been confirmed in children – review of 47 studies (Rampersaud et al., 2005) showed that breakfast eaters have higher daily intakes of fibre, calcium, vitamin A, vitamin C, riboflavin, zinc and iron compared to breakfast skippers. The *2005 Dietary Guidelines for Americans* identify whole grains, fat-free and low fat milk and milk products, fruits and vegetables as "*foods to encourage*". Popular breakfast foods help people meet recommendations for these food groups. Breakfast also contributes to whole grain intake (over 30% of the intake) which is known to reduce the risk of diabetes and coronary heart disease.

Milk is the most commonly consumed breakfast food (consumed by over 50% of people who eat breakfast at home) and this, again, helps to meet dietary recommendations for this type of food. Similar results have been reported for fruit intake, with fruit or fruit juice consumption at breakfast being linked with greater total fruit intake over the day (Quan et al., 2000).

Breakfast consumption has also been associated with better weight management. Results from the Seasonal Variation of Blood Cholesterol Study (SEASONS 1994-1998) show that the risk of obesity increases over four times in breakfast skippers compared to breakfast consumers (Ma et al., 2003). Other research shows that breakfast consumption is associated with lower BMIs (Cho et al., 2003) and a reduced risk of weight gain (van der Heijden et al., 2007). These results have been confirmed in studies of children and adolescents (e.g. Utter et al., 2007). Other research has examined which components of breakfast are related to better weight management and the findings support beneficial effects of cereal (e.g. Bazzano et al., 2005) and milk products (Zemel et al., 2004). Breakfast may also play a role in weight management by affecting satiety (Holt, Miller and Petocz, 1995; Blom et al., 2006).

1.2 Breakfast and physical health

Breakfast consumption is associated with lower levels of cholesterol (Stanton and Keast, 1989; Resnicow, 1991). Similarly, diets rich in fibre and whole grains are associated with a reduced risk of coronary heart disease (Djousse and Gaziano, 2007). Metabolic syndrome is a cluster of risk factors that are linked with being obese, having an increased risk of diabetes and coronary artery disease. Research shows that diets rich in whole grains and dairy

products (key components of many breakfasts) are associated with a reduced risk of metabolic syndrome (Baxter, Coyne and McClintock, 2006).

Dietary fibre from breakfast cereals may also improve digestion (Smith, 2010, b). There is also evidence that whole grain wheat may have a pre-biotic effect (Costabile et al., 2008) and that consumption of wheat bran can reduce levels of harmful bacteria such as *Clostridia* (Deaville, Gibson and Smith, in preparation). Eating breakfast also contributes nutrients that are important to bone health, with the main source being milk.

Other research (Smith and Rees, 2000; Smith, 2002a) has shown that breakfast consumption is associated with reduced susceptibility to the common cold. Smith (2002a) found that breakfast consumption was associated with lower cortisol levels. Cortisol often induces immuno-suppression and this provides a plausible mechanism for some of the health benefits associated with breakfast. Indeed, Li et al. (2007) found that breakfast consumption was associated with significantly higher numbers of NK cells and a significantly lower number of T cells than volunteers who did not regularly consume breakfast.

The main emphasis of the present chapter is on the behavioural effects of eating breakfast and these will be reviewed in the following sections.

2. Breakfast and cognitive function

2.1. Studies of adults

There has been considerable interest in the acute effects of meals on human performance and mood (see Smith & Kendrick 1992; and Mahoney, Taylor and Kanarek, 2005, for reviews). The overall aim of the present section is to review this evidence to determine whether breakfast influences mood and

performance, and to examine whether selective effects are observed depending on the type of meal eaten, task performed, characteristics of the person eating the meal and whether caffeinated beverages are consumed as part of breakfast.

It is often thought that consumption of breakfast enhances performance, a suggestion which has arisen largely from a series of studies by Tuttle and colleagues over 40 years ago ('the Iowa Breakfast studies'). The main aim of these studies was to evaluate the effects of varying breakfast regimes on physiological performance but a number of the studies also included some tests of mental performance. Tuttle, Wilson and Daum (1949), in the first experiment of the series, compared the effects of four breakfast regimes: (a) a heavy breakfast (b) a light breakfast, (c) no breakfast and (d) coffee only. Results showed that in the no-breakfast condition, there was a tendency towards slower reaction times. However, this was the only condition in which caffeinated coffee was not given and the results may reflect this. This was replicated when the same subjects were re-tested. Five out of six of the females showed a significant increase in simple reaction time in the no-breakfast condition, while three out of six showed a significant increase in choice reaction time in the same condition. Clearly results from studies with such a small number of subjects must be treated with caution.

Tuttle et al. (1950) carried out a similar experiment comparing breakfast and no-breakfast conditions, with testing taking place 3 hours after breakfast. Six of the ten subjects showed no change in reaction time in the no-breakfast condition (as compared to breakfast), three showed a significant increase in reaction times, while one subject's reaction time increased significantly during

the no-breakfast condition. Again, it is difficult to draw confident conclusions from such a study.

Another study (Tuttle et al. 1952) found no effect of breakfast on reaction times. Three breakfast conditions were compared: (a) bacon-egg and milk breakfast, (b) no breakfast, and (c) cereal and milk breakfast. Subjects (males aged 60 to 83 years) received the bacon-egg and milk breakfast for the first five weeks, followed by four weeks on no breakfast and four weeks on cereal and milk. Seven of the eight subjects showed no change in reaction times during the course of the experiment. Although this experiment has the advantage that it examined the long term effects of breakfast, the small sample size, poor experimental design and the use of only a few measures of performance limits its value.

These early studies have been criticised for having small numbers of subjects, for producing inconsistent findings and for the use of subjective assessments (Dickie & Bender 1982). The range of performance measures used was also small, being limited mainly to reaction time tasks. However, impaired performance associated with omitting breakfast was observed in other early studies. One study (King et al. 1945) assessed visual and motor functioning 2 h and 3 h after the consumption or omission of breakfast. The results showed that these functions were impaired when breakfast was not eaten compared to when it was.

Richards (1972) compared a standard breakfast with a no-breakfast condition. The volunteers were chosen so that half habitually ate breakfast and half no breakfast. A range of performance measures were employed: a visual search task, a short term memory task, vigilance task and a coding task.

Testing was carried out in the late morning. Participants were tested on five occasions: once following their normal breakfast, twice following the standard breakfast and twice following no breakfast. A modified Latin-square design was used to balance order of conditions. The consumption or omission of breakfast did not alter performance. Rather, performance was most impaired when subjects changed from their normal meal. This led to the view that 'the occasional omission of breakfast is more deleterious than the constant omission'.

Benton and Sargent (1992) compared the effects of no breakfast and consumption of a high protein drink on spatial memory and immediate recall of a word list. Half the subjects were habitual breakfast eaters and half did not usually eat breakfast. Consumption of the high protein drink increased the speed with which both memory tasks were completed. Benton and Parker (1998) confirmed that breakfast improves aspects of memory and suggested that this may reflect several different mechanisms.

Other studies have suggested that the size and composition of breakfast influence the post-meal response. Lloyd et al. (1996) compared low fat/high carbohydrate, medium fat/medium carbohydrate, high fat/low carbohydrate and no-breakfast conditions. No clear differences in performance were observed as a function of type of breakfast but subjects given the low fat/high carbohydrate breakfast (which was most similar to their normal meal) reported improved mood compared to the other conditions. Nabb and Benton (2006) compared breakfasts that contained either high or low levels of carbohydrate, fat or protein. Better memory was associated with consumption of meals that more slowly released glucose into the blood. This benefit of a low glycaemic

index breakfast has been confirmed in animal studies (Benton et al., 2003) and in children (Wesnes et al., 2003; Ingwersen et al., 2007).

The next section reports two studies (Smith, Kendrick and Maben, 1992; Smith et al., 1994) which examined the effects of breakfast on mood and a range of different aspects of performance. The type of breakfast was manipulated and the influence of caffeinated drinks examined. The experiments also investigated whether personality, eating habits, gender and previous night's sleep modified any effect of breakfast on behaviour. The first experiment examined the effects of two types of breakfast on sustained attention tasks (i.e. tasks which show an effect of lunch), mood and cardiovascular functioning. Volunteers were given either caffeinated coffee or decaffeinated coffee after the meal (or no meal). This was done to investigate whether caffeine modified any effects of breakfast, and secondly, as a positive control to show that the tests used here were sensitive to changes in state produced by caffeine (Lieberman 1992).

In the first study a between subject design was used and volunteers were assigned to one of the six conditions formed by combining the three breakfast and two caffeine conditions. Volunteers were either assigned to a no-breakfast condition, a cooked breakfast condition or cereal/toast breakfast. Details of these are shown below:

(1) Cereal/toast breakfast: 1 oz. cornflakes; 150ml skim milk 2tsp sugar; 1 slice wholemeal toast; 10g polyunsaturated margarine/butter; 25g marmalade.

(2) Cooked breakfast: 2 eggs, scrambled skim milk; 2 thin slices back bacon; 1 slice wholemeal bread/toast;

10g polyunsaturated margarine/butter

After breakfast participants were either given de-caffeinated coffee or de-caffeinated coffee with 4 mg/kg of caffeine tablets added.

Breakfast had no effects on performance of sustained attention tasks. In contrast, caffeine improved performance of these tasks. No interactions between breakfast conditions and personality were found in any of the analyses. Similar results were found when gender was included as a factor.

Smith et al. (1994) examined effects of breakfast on performance of memory tasks. Consumption of breakfast improved recall and recognition of a list of words but had no beneficial effects on working memory or semantic memory tasks. Again, effects of breakfast were not modified by caffeine or by personality and gender. Breakfast had no effect on free recall in the late morning or after lunch, which suggests that the effects of breakfast on episodic memory are restricted to a few hours after the meal.

Smith, Clark and Gallagher (1998) extended the above results by showing that consumption of breakfast may also improve spatial memory. However, the most robust effects of breakfast on memory are found in free recall tasks and these effects have been observed after consumption of high carbohydrate cereals (Smith, in preparation, a) and cereal bars (Smith and Wilds, 2009; Smith and Stamatakis, 2010). Similarly, a mid-morning cereal bar may also have beneficial effects when consumed after a small breakfast (Smith and Wilds, 2009).

There have been a few studies that have examined effects of breakfast in elderly adults. Early studies by Tuttle and colleagues (Tuttle et al., 1952, 1953) found little evidence for an effect of breakfast on the cognitive function

of elderly people. Recent studies have demonstrated both acute effects of breakfast and effects of the breakfast habit. Kaplan et al. (2001) found that carbohydrate intake was associated with improved performance of a short-term memory task whereas a protein breakfast was associated with reduced forgetting in a paragraph recall task. Smith (1998) found that elderly adults, aged between 60 and 79 years, who ate breakfast cereal every day performed better on a test measuring intellectual functioning than those who consumed breakfast less frequently. It should be noted that this last result could reflect an effect of intelligence on breakfast consumption rather than a causal effect of breakfast consumption on intelligence. Further intervention studies are needed to assess the effects of breakfast on cognitive function in the elderly.

2.2.1 Studies of children

There have been a number of reviews of the effect of breakfast on the cognitive performance of adolescents and children (Rampersaud et al., 2005; Mahoney, Taylor and Kanarek, 2005; Hoyland, Dye and Lawton, 2009) and the main findings can be summarised as follows. There have been over forty studies published on this topic (see Appendix 1) in the last 60 years (see Hoyland, Dye and Lawton for details of the literature). The results confirm the adult literature showing that breakfast has a beneficial effect on cognition, with the strongest support for improvements in memory. This effect is most readily apparent when nutritional status is compromised. Less is known about the effects of different types and sizes of breakfast so the role of breakfast size and composition requires further consideration. Wyon et al. (1997) reported that children did better on tests of creativity, physical endurance and

mathematical ability when they consumed a high energy breakfast compared to consumption of a low energy breakfast. Michaud et al. (1991) confirmed these results using a short-term memory task. Other studies (Mahoney et al., 2005) report an oatmeal breakfast leads to better performance compared to a ready-to-eat cereal (especially in girls).

Most studies have investigated children rather than adolescents. A recent study of high school students (Widenhorn-Muller et al., 2008) showed that breakfast had no effect on sustained attention but improved visuo-spatial memory in males. Studies of school breakfast programmes suggest that such interventions can have positive effects which may reflect an effect of these programmes on school attendance. In addition, breakfast consumption in children and adolescents is associated with a superior nutritional profile and better weight management.

3. Effects of breakfast on mood

A number of studies have shown that consumption of breakfast is associated with a more positive mood including greater alertness, hedonic tone and a reduction in anxiety in the period shortly after consumption. Maridakis, Herring and Connor (2009) demonstrated that these effects could be demonstrated using a range of differing measuring instruments. Similarly, they have been found with different types of breakfast (e.g. Smith, Kendrick and Maben, 1992**)** and when volunteers were free to select from a range of breakfast cereals (Smith, Clark and Gallagher, 1999) or cereal bars (Smith and Wilds, 2008). These results have been confirmed in studies of adolescents (Widenhorn-Muller et al., 2008) and children (Smith, in press). Other research has suggested that different macronutrients have selective

effects on mood (e.g. simple versus complex carbohydrates, Pasman et al., 2003) although it is often unclear whether such effects reflect factors such as acceptability. Similarly, some research suggests that mood is more negative after a low energy rather than high energy breakfast (Lluch et al., 2000). Effects of habitual consumption may also modify the acute effects of breakfast, with deviation from habitual breakfast being associated with a more negative mood (Lloyd et al., 1996). The effects of habitual breakfast consumption patterns on longer term well-being will now be considered.

4. Breakfast and well-being

Smith (2003) has discussed the relevance on the concept of well-being in nutrition research. The concept of well-being has become increasingly important since the acknowledgement that there is more to health than the absence of disease. In some areas of research well-being has been replaced by "quality of life" or some other term that relates to the ability to function well (both physically and mentally) and to have a positive mood state. In the area of nutrition the term "functional food" is widely used and this refers not only to the beneficial effects related to chronic disease but to potential improved well-being. Consumption of breakfast has been shown to be associated with various aspects of the multi-dimensional concept of well-being and some examples are given in the following section.

Wetzler and Ursano (1988) showed that breakfast consumption was associated with better psychological well-being in a cross-sectional analysis of over 6,000 individuals. Similarly, Tanaka et al. (2008) found that skipping breakfast was associated with an increased prevalence of fatigue in medical students. In the largest study, Huang et al. (2010) examined associations between breakfast

skipping and health-related quality of life in a national representative sample (N=15,340) from the 2005 Taiwan National Health Interview Survey. The results showed that breakfast skippers had significantly lower scores (poorer well-being) on 5 out of the 8 domain scores on a quality-of-life questionnaire, the SF-36 (lower general health; reduced vitality; poorer social functioning; poorer emotional roles; and reduced mental health).

Smith (1998) examined the relationship between breakfast consumption and subjective reports of health and health related behaviours in a general population sample (126 subjects aged between 20 and 79 years). Individuals who consumed a cereal breakfast each day were less depressed, less emotionally distressed and had lower levels of perceived stress than those who did not eat breakfast each day. Those who consumed breakfast had a healthier life style than the others as they were less likely to be smokers, drank less alcohol and had a healthier diet. However, the relationship between cereal breakfast consumption and health was present regardless of differences in the other health-related behaviours.

A subsequent study (Smith, 1999) attempted to replicate and extend the above result. The general population sample in this study (262 volunteers aged between 21 and 85 years, mean age: 60.9 years) was older than the sample in the previous study. Individuals who consumed breakfast cereal everyday reported better mental and physical health than those who consumed it less frequently. This association was still present when demographic factors, indicators of lifestyle such as smoking, or other aspects of diet were covaried.

Smith (2003) continued to study this topic and in the next study considered young adults (189 volunteers, aged between 19-21 years, mean age 19.6 years) living at home. The results showed that skipping breakfast was associated with reports of poorer health and that regular breakfast cereal consumption is associated with better reported health. The effects of breakfast could not be explained by other health-related behaviours or other aspects of diet.

In the latest study (Smith, 2010,a) the sample were two hundred and thirteen children, (108 female, 105 male; mean age: 8.11 years, s.d. 2.04 years), recruited from schools in Cardiff, Wales. Baseline measures of breakfast consumption and different aspects of reported well-being, such as mental health; cognitive functioning; alertness; physical health; and digestive problems, were recorded. Following this children were allowed to try three cereals and selected the one that they found most acceptable (63 choose *Cornflakes;* 63 *Rice Krispies***;** and 53 *Rice Krispies Multigrain*). The groups consumed these cereals on a daily basis for two weeks. Measures of well-being were recorded on days 7 and 14. The breakfast cereal groups were compared with 34 children who consumed no breakfast. The baseline results showed that those who consumed breakfast cereal were perceived as having better well-being including fewer mental health problems, a more positive mood, higher alertness and fewer bowel problems than those who did not consume breakfast. This was confirmed in the intervention study with breakfast cereal consumption being associated with reports of lower depression, emotional distress and fatigue, greater alertness, fewer cognitive problems, and fewer minor symptoms and bowel problems.

These effects were apparent after both the first and second week. They were also observed for all cereals. Overall, the results of this study show that breakfast cereal consumption by children is associated with greater well-being. There is evidence that breakfast consumption per se improves well-being and effects appear to be most pronounced with breakfast cereal in combination with dairy products (O'Sullivan et al, 2009). One type of breakfast cereal that has a large effect is high fibre cereal. Research has also shown that increasing dietary fibre from wheat bran cereals decreases fatigue and increases energy (Smith *et al*., 2001). Smith (in press, b) conducted secondary analyses of data from this study. Initial analyses examined associations between high fibre intake and well-being (emotional distress, fatigue, cognitive difficulties and somatic symptoms). The results showed that high fibre intake was associated with increased well-being. Subsequent analyses examined whether the effects of total fibre intake could be accounted for by ingestion of specific sources of fibre, namely breakfast cereal and fruit/vegetables. The results showed that it was the breakfast cereal that was largely responsible for the increased well-being. Digestive problems are also associated with reduced well-being and a second set of analyses examined whether the benefits of fibre were due to a reduction in digestive problems. The results showed that digestive problems reduced well-being but these effects were independent of the effects of fibre.

The next section considers mechanisms that might underlie behavioural effects of breakfast.

4. Underlying mechanisms

4.1 Breakfast is better than nothing

Results clearly show that consumption of breakfast improves mood and cognition compared to eating no breakfast. It has been suggested that breakfast removes the negative effects of fasting and the mechanism has often been conceptualised in terms of providing a supply of energy to the brain (see next section). However, recent research suggests that the mechanisms are likely to be more complicated. In a series of studies Smith (in preparation, b) examined when consumption of breakfast cereal led to an improvement in mood and memory. The first study examined effects observed after a cereal lunch (following consumption of a normal breakfast). The cereal consumption was associated with a more positive mood but no benefits were seen for the free recall task. This suggests that it is not just the meal that is important. A second study examined effects of consuming cereal in the early evening after a day of fasting. Fasting led to a more negative mood and impaired free recall of a list of words. Consumption of cereal improved mood but did not improve memory. This result suggests that fasting is not the only factor involved in the acute effects of breakfast. Finally, the effects of breakfast on the mood and memory of night workers (who slept during the day and had breakfast in the evening) were investigated. Again, breakfast improved mood but had no effect on memory. These results suggest that consumption of breakfast cereal improves mood whenever it is eaten but the memory effects depend on it being consumed early in the day.

The effects of breakfast, or rather a high carbohydrate breakfast, have often been explained in terms of changes in serotonin (Fernstrom and Wurtman,

1971). Such a mechanism could explain the association between regular consumption of breakfast and well-being, although it may also be the case that it is well-being that influences food choice (Christensen and Somers, 1996). It is likely to be the case that a number of peripheral and central mechanisms underlie the effects of breakfast on behavior and further research is required to elucidate these mechanisms. The next section considers the importance of the macronutrient content of breakfast.

4.2 Glycaemic index/load

A large number of studies have examined the effects of glucose on behaviour. The evidence for positive effects is not consistent although a number of studies have demonstrated beneficial effects of glucose on verbal memory (Hoyland, Lawton and Dye, 2008). Other studies have investigated the effects of meals differing in glycaemic index, glycaemic load, the ratio of slow/rapid availability of glucose, the proportion of simple to complex carbohydrate, or the amount of rapidly versus slowly digested carbohydrate. Glycaemic index (GI) and glycaemic load (GL) are the most widely used indices. GI provides a measure of carbohydrate quality not quantity, whereas GL is a product of the food's GI and the amount of carbohydrate per serving. Gilsenan, de Bruin and Dye (2009) have reviewed studies comparing the impact of different GLs. Their conclusion was that there is insufficient evidence to support a consistent effect of GL on cognitive performance. A recent study (Micha, Rogers and Nelson, 2010) examined the effects of glycaemic potency (combinations of GI and GL) on cognitive performance of sixty children aged 11-14 years. A low-GI/high GL breakfast was associated with faster information processing whereas a high GI breakfast was associated with better immediate word

recall. Further research is now required to determine whether breakfasts with these macronutrient compositions will have beneficial effects on the academic performance of children. The research to date does not inform on the precise mechanisms through which glucose influences cognition. The possible mechanisms are many and varied. For example, glucose is taken up by astrocytes, converted into lactate which is then released into extra cellular space to be taken up as an energy substrate by neurons. Many of the brain's neurotransmitters are derived from glucose metabolism which suggests that glucose may influence cognitive function by enhancing neurotransmitter synthesis during periods of neuronal activity. Alternatively, there could be a peripheral effect of glucose on memory due to a neural signal being triggered when glucose is transported into cells. GL may also influence gastro-intestinal hormonal response which in turn may have effects on cognition. Factors such as food acceptability may also be related to levels of circulating glucose and these variables must be controlled when assessing the impact of different meals.

4.3 Other mechanisms

There are clearly a number of other mechanisms through which consumption of breakfast may influence behavior. These may reflect the macronutrient composition (e.g. effects of high fibre cereals), the micronutrient composition (e.g. fortification of cereals) or a more general influence on dietary intake and health.

5. Effects on real-life cognitive function and safety

The major practical implications of breakfast consumption are to be seen in the areas of nutritional intake, weight management and health. Studies of

children suggest that breakfast consumption may improve cognition and school attendance which leads to better academic achievement. Reviews of breakfast consumption and children's academic achievement (e.g. Ells et al., 2008) have concluded that there are short-term benefits. However, they also point out the methodological problems present in many of the studies: failure to consider the impact of habitual diet; little consistency in the methodology across studies; use of measures with no known validation; failure to distinguish nutritional effects from the social effects of breakfast clubs; and, given most interventions have been of short duration, the results fail to quantify sustainability and longer term benefits.

Little is known about the real-life behavioural implications of consuming breakfast for adults. For example, a literature search revealed no information on breakfast and accidents and errors at work (or outside of work), road traffic accidents or driving performance, or on productivity at work. There is a link between performance of laboratory tasks and safety issues in that Morris (2008) found that elevating blood glucose level increased the retention of information from a public safety video.

Chaplin and Smith (submitted) examined effects of breakfast consumption on the health and safety of a sample of 870 nurses. The results showed that accidents, injuries and cognitive failures at work were greater in those who rarely ate breakfast. In addition, stress at work was greater in the breakfast skippers. Further research is now required to extend these findings to consider real-life activities outside of the workplace. In addition, it is essential to carry out interventions rather than just cross-sectional analyses.

6. Discussion

The obvious conclusion to be drawn from the literature reviewed here is that breakfast is good for you. This is true when one considers a number of different areas such as nutritional intake, weight management and health. The same conclusion applies when one considers behavioural outcomes, with breakfast being associated with a more positive mood, improved cognition and, in the longer term, better well-being. These conclusions generally hold for well-nourished children, children with nutritional deficiencies and adults (young, middle-aged and the elderly). Given the robust evidence for beneficial effects of breakfast it is rather surprising that we have made relatively little progress in understanding the underlying mechanisms (both psychological mechanisms and the CNS changes that underpin these). Furthermore, compared to other aspects of eating and drinking (e.g. consuming caffeine) we know relatively little about the practical benefits of breakfast at work, rest and play. Future research must extend our current knowledge by conducting translational research that will provide appropriate information for future policy and practice.

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8. Appendix

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