BREAKFAST AND COGNITIVE FUNCTION IN 10-YEAR OLD PRIMARY SCHOOL CHILDREN IN PENAMPANG, SABAH

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I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

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ABSTRACT

Relationship between breakfast omission and cognitive performance was investigated in primary school children using a cross-over, within-subject design. Subjects from SRK St. Joseph Penampang (n=51; m=25; f=26; age 10y) were recruited. Pre-preparation was an overnight fast but non-compliance was 39.6%. However results from non compliers to the overnight fasting protocol were not significantly different from compliers irrespective of treatment groups. On assessment day, subjects were randomly assigned to receive breakfast (BR) or no breakfast (NBR) in school. One week later, treatment groups were reversed. Breakfast treatment was a *kaya* sandwich, a 200ml chocolate malt drink and a common variety banana (approximately 413 kcal). One hour after treatment, subjects completed four cognitive tasks for: (1) short-term memory (Serial Recall Task, SRT and Brown-Peterson Task, BPT), (2) spatial memory (Spatial Memory Task, SMT), and (3) attention (Visual Search Task, VST). Brown-Peterson Task was not further analysed due to incorrect data. BR subjects performed better than NBR subjects in SRT, especially as serial positions progressed ($p<0.05$). NBR subjects significantly made more errors than BR subjects ($p<0.05$). BR subjects performed worse than NBR subjects in SMT and VST, albeit insignificant differences ($p>0.05$). Findings from the VST were congruent with Dickie & Bender (1982) and Chandler *et al.,* (1995). Findings differed from Mahoney *et al.* (2005) in SMT. Poorer BR subjects (household income <RM1000/mo) performed significantly better for spatial ($p<0.05$). Thin NBR girls were severely affected in SRT ($p<0.05$). These findings could be due to (1) the level of food deprivation between compliers and non-compliers; (2) the breakfast treatment (i.e. glycaemic composition); and (3) nutritional status of the subjects. In conclusion, breakfast omission significantly affected short term memory, ($p<0.05$) but not for attention and spatial memory ($p>0.05$).

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LIST OF ABBREVIATIONS

BMI	-	Body Mass Index
BMI/A	-	BMI-for-Age
BPT	-	Brown-Peterson Task
BR	-	Breakfast treatment group
GI	-	Glycaemic Index
H/A	-	Height-for-Age
Kcal	-	kilocalorie / calorie
NBR	-	Non-breakfast treatment group
PLI	-	Poverty Line Index
PSS	-	School Milk Programme / *Program Susu Sekolah*
RDA	-	Recommended Daily Allowance
RNI	-	Recommended Nutrient Intake
SD	-	standard deviation
SE	-	standard error
sec	-	second
SES	-	socioeconomic status
SMT	-	Spatial Memory Task
SRT	-	Serial Recall Task
SSFP / RMT	-	School Supplementary Feeding Programme/ *Rancangan Makanan Tambahan*
STM	-	Short Term Memory
VST	-	Visual Search Task (Cancellation Test)
W/A	-	Weight-for-Age
W/H	-	Weight-for-Height
WHO	-	World Health Organisation
WISC	-	Weshler's Intelligent Scale for Children
WRAT	-	Wide Range Achievement Test

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CHAPTER 1

INTRODUCTION

1.1 Breakfast

Regardless of the many meals an individual can have in a single day, breakfast has earned the title as the most important meal of the day contributing substantially to daily nutrient intake and energy needs (Mahoney *et al.,* 2005). As the word suggests, "breakfast" literally means "to break fast" as breakfast is typically eaten after a night's rest, also considered as a "fasting period". Ruxton *et al.* (1996) defined breakfast as any solid item of food taken before arriving and attending school, while the definition of breakfast according to Dickie & Bender (1982) focused on any solid food taken on the morning of the test. Therefore, the definition of breakfast for this study combined both definitions – breakfast: any solid item of food taken before attending school, on the morning before partaking in the test.

Overseas, types of foods consumed at breakfast across various population groups showed milk is one of the most consumed foods by children at breakfast in the United States, Canada and Europe (Rampersaud *et al.,* 2005). Besides that, they also noted that breakfast cereals, which are usually consumed with milk, are also popular in the United States, Canada, the United Kingdom, Spain and Croatia. Various types of breads are also commonly consumed during breakfast. There have been changes observed in breakfast consumption patterns over a 26-year period; increased consumption of low-fat milk, ready-to-eat cereals, and juices and the decreased consumption of high-fat milk, whole-grain breads and eggs (Rampersaud *et al.,* 2005).

In Malaysia, breakfast types may differ according to culture and ethnicity. Breakfast may consist of a popular Malay food such as *nasi lemak*. Other foods such as roti canai, kaya toast, half boiled eggs, wonton noodles and rice congee are also among the favourites. In the Peninsular Malaysian East Coast, in addition to the above mentioned varieties, glutinous rice is sometimes eaten at breakfast, as are some types of sweet potatoes and cassava.

Studies have been done on the role of breakfast consumption among children and adolescents and its relationship in more specific areas, such as nutrient adequacy (Rampersaud *et al.,* 2005) and quality of diet, obesity (Panagiatakos *et al.,* 2007), improvement in student behaviour and learning environments, school attendance rates (Powell *et al.,* 1998), decreased absence and tardiness rates, punctuality and psychosocial functioning (Murphy *et al.,* 1998). Cueto & Chinen (2008) evaluated educational impacts of school breakfast in rural Peru, and found positive effects on school attendance and drop-out rates. Rampersaud *et al.* (2005) also reviewed breakfast roles in areas of body weight and BMI in children and adolescents. According to Panagiatakos *et al.* (2007), daily consumption of breakfast is inversely associated with the prevalence of overweight or obesity in 10 to 12-year-old children. Besides that, Rogers (1997) noted how bad behaviour and bad eating habits in children can be explained as in the existence of a probable association between difficult home circumstances and relatively poor academic performance.

Sometimes, breakfast is consumed based on timing and availability, with foods that could be consumed readily and obtained on-the-go such as ready-to-eat cereals, pre-packed breads/biscuits or boxed drinks/juices, more preferred. Other times, it is often missed as noted by Affenito (2007). Brugman *et al.* (1998) noted that skipping breakfast or inadequate breakfast consumption in children contributes to dietary inadequacies that are seldom compensated for in other meals. Breakfast skipping has clearly been shown to be a detrimental health practice for all ages of youth resulting in decreased daily intakes of metabolic regulators essential for growth and health (Hill, 1995). In a study of the impact of breakfast consumption on nutritional status of the diets of young adults (Nicklas *et al.,* 1998), 37% of young adults skipping breakfast also reported lower total daily intakes of energy, protein per 1000 kcal, and saturated fat per 1000 kcal than those who consumed breakfast.

1.2 Breakfast and Cognitive Function

In the interest of this study which focused on the effects of missing breakfast on cognition in school children, several studies suggested that prolonged fasting could affect cognitive functions such as memory, impair academic performance, and also affect emotions and mood (Pollitt, 1995).

In the 1980s, Pollitt *et al.* (1981) studied the effects of brief fasting and stress on cognition (speed and accuracy in problem-solving tasks) in children. The study revealed that stress (defined as brief fasting) interfered with ability to discriminate between relevant and irrelevant features of visual stimuli in order to match identical figures. Cueto & Chinen (2008) evaluated significant and positive effects on short term memory, arithmetic and reading comprehension in multiple-grade schools.

Hypothetically, two probable biological mechanisms have been suggested on how breakfast could affect brain function and cognitive test performance. The first involves short-term metabolic changes linked with an overnight fast to maintain the availability of fuel and other nutrients to the central nervous system. The other involves the long-term beneficial changes that breakfast could have on nutrient intake and nutritional status, which in turn, can affect cognition (Pollitt & Matthews, 1998). This second mechanism is particularly relevant for children whose daily dietary intake barely meet requirements (Pollitt, 1995).

1.3 Objective

The study had three objectives:

1. To examine the effects of breakfast omission on cognitive functioning (i.e. cognitive test performance) in primary school children.
2. To examine the relationship between socioeconomic status factors and breakfast consumption of primary school children and cognitive functioning.
3. To examine the nutritional statuses of the 10 year old primary school children (Standard 4) using anthropometric measurements.

1.4 Hypothesis

This study hypothesised that breakfast omission in primary school children aged ten years (Standard 4) would result in poor cognitive functioning (i.e. poor cognitive tasks performances).

1.5 Rationale

Since the beginning of the 1980s, studies on the relationship between breakfast effects on cognitive functioning have been continuously expanding and evolving, providing crucial yet inconsistent results along the way. While many researchers overseas have studied relationships between breakfast and cognition, relatively few have been done in Malaysia.

Studies which focused on food insufficiency on children's cognitive development (Alaimo *et al.,* 2001) and breakfast composition on cognitive processes (Mahoney *et al.,* 2005) were done in the United States. A number of studies which reported adverse effects of overnight fasting and breakfast omission on cognitive functioning in children were done in the United States (Pollitt *et al.,* 1981; Pollitt *et al.,* 1998), in Jamaica (Chandler, 1995; Simeon & Grantham-McGregor, 1989), United Kingdom (Dickie & Bender, 1982) and also Peru (Cueto *et al.,* 1998). Brugman *et al.* (1998) studied associations of breakfast skipping with socio-demographic variables in the Netherlands.

In Malaysia, several studies have been done on children's nutritional status and cognitive development, but focused more on children's overall dietary intakes as opposed to only breakfast consumption. For example, a study by Sarina *et al.* (2005) was done among Malay and Indian primary school children in Standard 2 and 3 in Hulu Selangor using the McCarthy's Scale of Children Abilities (MSCA) instrument to assess cognitive development. Another cross sectional study (Pook & Norimah, 2005) tested Chinese school children aged 9 to 12 years on the Weshler's Intelligent Scale for Children (WISC, 3rd edition) in Kuala Lumpur. Haslina *et al.* studied household socioeconomic status, nutritional status and intelligent quotient (IQ) among Arang Asli children aged 3 to 8 years old in Sepang District and Carey Island, Banting.

All these studies used the 24-hour Diet Recall to measure children's overall dietary intakes (NSM, 2005).

A study which was carried out in four regions of Peninsular Malaysia, Sabah and Sarawak investigating food habits and physical activity pattern among primary school children in Malaysia reported that Sabah had the highest prevalence of breakfast skipping in the country (Norimah *et al.,* 2009). As such, this study could serve to shed more light on the effects of breakfast (omission or consumption) on children's cognitive function in Sabah, as primary school children from SRK St. Joseph, Penampang were recruited.

The selection of children aged ten years, was based on the many studies done previously which investigated children of the same age range. Pollitt *et al.* (1981) examined well-nourished 9 to 11 year old boys and girls, while the study by Simeon & Grantham-McGregor (1989) was done on children of the same age group but were grouped according to nutritional status. Children with an average age of 12.5 years were used in Dickie & Bender's (1982) investigation of breakfast and performance. Cueto *et al.* (1998) studied nutritionally at-risk boys with a mean age range of 10 to 11 years while Chandler *et al.* (1995) explored school breakfast effects on 11 year old boys and girls from rural schools. Therefore, a study done locally using the same age group could provide relevance when results are discussed.

It had been hypothesised that brain function in young children whose cognitive processes are still maturing is vulnerable to metabolic stresses of fasting. Since they are more likely to be susceptible to these stresses, they are most likely to benefit from breakfast consumption (Pollitt & Matthews, 1998). Alaimo *et al.* (2001) reported that younger food-insufficient children scored lower reading and arithmetic scores. Powell *et al.* (1998) reported significant benefit of breakfast to rural, primary school children's achievement in arithmetic among the younger children of Grades 2 and 3 (ages 7 and 8 years), in particular among girls. These studies compared the availability of breakfast; the composition of the breakfast itself was not evaluated. The present study would use the same framework on Malaysian children, to see if the backgrounds of the students are from poor households. Although breakfast composition (e.g. Glycaemic Index, GI) has been shown to be a significant factor in cognitive function, the priority here is to investigate effects on breakfast omission.

The study could also serve to assist in increasing knowledge and awareness of the importance of breakfast in children among parents, guardians and teachers. By examining the possible relationships that exist in terms of breakfast omission with cognitive functions, parents/guardians could be encouraged to provide their children with morning meals before arriving to school. Furthermore in the long run, this study would provide data that could be used to facilitate in the structuring of school-based programmes, regardless whether feeding or academic related.

CHAPTER 2

LITERATURE REVIEW

2.1 Children's Daily Nutrient Requirements

Being the first meal of the day, breakfast is brain food as it provides the first dietary energy source for the day (Grosvenor & Smolin, 2002). The Iowa Breakfast Studies defined a basic breakfast as one that provides one fourth the total daily caloric requirement and one-fourth the total daily protein allowance (Morgan *et al.,* 1981). Children require certain amounts of macro- and micronutrients in their daily food intake in order to support their growing and maturing bodily functions. Children need energy and protein for growth as well as to maintain body tissues. Despite their growth and metabolic rates slowing down as they mature (nutrient requirement per unit of body weight decreases), however the total needs for energy and protein increases because body size increases and they become more active (Grosvenor & Smolin, 2002).

The Recommended Nutrient Intakes (RNI) for energy in boys aged 10 to 12 years is 2180 kcal daily while girls in the same age group require 1990 kcal. Protein requirement in boys with the same age group is 45g while girls require 46g of daily protein intake (MOH, 2005). For carbohydrates, children above the age of two are recommended to obtain about 55–60% of total daily energy, with carbohydrate sources coming more from the complex variety (Grosvenor & Smolin, 2002). Micronutrient needs are important as well to help in growing body functions. According to a survey done in the USA, children there are most likely to be deficient in folate, vitamins A, B6, C, E as well as minerals such as calcium, iron and zinc (Grosvenor & Smolin, 2002).

2.2 Breakfast and Children's Nutritional Adequacy

In a review by Rampersaud *et al.* (2005), based on studies carried out in US populations of children from 5 to 18 years of age, mean energy intake at breakfast ranged from 275–669 kcal, and percentage contributions to total energy from carbohydrate, protein and total fat ranged from 49–72%, 11–16%, and 14–40% respectively. Breakfast eaters tended to have higher total daily intake of energy and micronutrients compared with non breakfast eaters. Besides that, high energy types of breakfast were associated with higher mean daily intake of carbohydrates and a lower intake of lipids compared with lower energy breakfasts.

In a study by Ruxton *et al.,* (1996), breakfast was reported to contribute 14% of energy, 10% of fat, 16% of protein, 18% of carbohydrates, and 9–36% of micronutrient intakes to the overall diets of 7 to 8 year old children. In particular a breakfast containing ready-to-eat breakfast cereals (RTEBC) eaten frequently, had a strong influence on the daily energy intakes of 7 to 8 year old children, especially by lowering the ratio of energy from fat.

According to Morgan *et al.* (1981), children considered to be ready-to-eat cereal eaters (those consuming at least three breakfasts, out of possible seven, that included ready-to-eat cereal) ate breakfasts which, on the average, contained less fat and cholesterol, one and a half times more thiamin, riboflavin, folacin, and vitamins B12 and D; and two times as much crude fiber, niacin, vitamin A, and pyridoxine. Regular breakfast eaters (particularly those who eat breakfast cereals) benefited from the higher average content of ascorbic acid, thiamin, niacin, riboflavin, folacin, calcium, phosphorus, iron, potassium, copper, zinc, magnesium, pyridoxine, and vitamins B12, A, and D. Breakfasts which contained no ready-to-eat cereal had a higher average content of calories, protein, fat, cholesterol, and sodium.

A review by Ruxton & Kirk (1997) noted that breakfasts, with the inclusion of breakfast cereals were more nutrient dense and lower in fat than in any other types of breakfasts. It concluded that breakfast consumption was a marker for a appropriate dietary pattern with regards to both macro- and micronutrients, particularly if breakfast cereals were included in the meal.

In a subject sample of children aged 2 to 10 years and adolescents, Preriosi *et al.* (1999) reported that breakfast supplied 12–18% of energy following the RDAs. Carbohydrates supplied 57–62% of breakfast energy; proteins supplied 11–13% while fats supplied 27–30%. As for vitamins, breakfast contributed more than 50% of vitamin B2 in children, more than 20% of vitamin B1, 10-15% vitamins A, B6, and C. Besides that, it was reported that intakes of micronutrients were: 45% of RDA for calcium and phosphorus, 33% of RDA for magnesium and 10–15% for iron, zinc and copper.

In Malaysia, one study (Moy *et al.,* 2006) looked into the eating patterns of school children and adolescents (Standard 5, Secondary 2 and Secondary 4) in Kuala Lumpur. They found that 19.9% skipped at least one meal a day with the youngest group having the lowest prevalence. The most frequently missed meal is breakfast (12.6%) followed by lunch (6.7%) and dinner (4.4%). They also found out that most of the subjects were eating out at hawker stalls or fast food chains while the youngest group had high prevalence of snacking. However, detailed information on the children's and adolescent's nutritional status was not investigated. Yet, that particular study showed the increasing prevalence of breakfast skipping in Malaysian school children, particularly as their ages increased.

Literature has considered the probable vast benefits of breakfast in supplying all the daily nutrient intake and energy needs among children. It is therefore essential that breakfast consumption be one that is of balance and moderation, combining different food groups to achieve a complete morning meal.

2.3 Assessing Children's Growth and Development

Recommendations for children are important to supply all necessary nutrients in sufficient amounts in order to cope with the child's rapid growth and development as well as for activity and maintenance (Grosvenor & Smolin, 2002). Growth is most rapid in the first year of life, with an increase of about 10 inches or 50% increase in infant's length. As the infant's age increases, its growth rate slows down with only an increase of about 2–3 inches per year (Grosvenor & Smolin, 2002).

Monitoring children's growth is vital in ensuring proper development. This can be done by comparing their growth patterns to standard growth patterns using growth charts. Anthropometric indices, weight-for-age (WA), height-for-age (HA) and weight-for-height (WH) are used as the main criteria for assessing adequacy of diet and growths (WHO, 1995) as well as the overall nutritional status in infants and children. Recently, the 2007 WHO Reference Growth Charts has been introduced worldwide with the aim to provide a guideline to assess the nutritional status of children and teenagers within the ages of five to nineteen years (WHO, 2007). All these indices can be deduced when plotting the respective measurements on the respective growth charts.

The WHO (2007) classification of BMI-for-Age (BMI/A) reflects the body mass relative to chronological age. As age increases, so does the body's need for energy. When insufficient energy is supplied to the body, weight will decrease. It is a form of malnutrition in children who are unable to reach the normality range ($-2SD \leq$ z-score $\leq +1SD$; 2.3^{rd} percentile $\leq$ Z-scores $\leq 97.7^{th}$ percentile; or 5^{th}-95^{th} percentiles). Classification for Height-for-Age (H/A) reflects achieved linear growth and its deficits indicate long-term, cumulative inadequacies of health and nutrition. "Height" can also be referred to as "length" (for infants) or "stature" depending on the circumstances. The weight-for-height classification reflects the body weight relative to height. It is used to determine conditions such as wasting, thinness, overweight or obesity in subjects.

Categorisation of children according to the WHO BMI/A reference (WHO, 2007):

Severe thinness	: Below -3SD of WHO BMI/A median
Thinness	: -3SD ≤ to < -2SD of WHO BMI/A median
Normal	: -2SD ≤ to < 1SD of WHO BMI/A median
Overweight	: 1SD ≤ to < 2SD of WHO BMI/A median
Obese	: Above 2SD of WHO BMI/A median

Categorisation of children according to the WHO H/A reference (WHO, 2007):

Significantly stunted	: Below -3SD of WHO H/A median
Mildly stunted	: -3SD ≤ to < -2SD of WHO H/A median
Normal	: -2SD ≤ to < 1SD of WHO H/A median
Tallness	: Above 2SD of WHO H/A median

While growth very much depend on other factors such as genetics, lifestyle and the environment, it is generally accepted that diet plays a major factor in children's overall development. Therefore, monitoring growth and physical development in infants & children is an important indicator for their nutritional status.

2.4 Cognition and Cognitive Function

The term "cognition" (Latin: cognoscere, to know) is the process involved in knowing, or the act of knowing, which comprehensively includes perception and judgement. Cognition includes all processes of consciousness where knowledge is accumulated, such as perceiving, recognising, conceiving and reasoning. It is an experience of knowing that can be distinguished from an experience of feeling or willing (Encyclopedia Brittanica, 2008).

In cognitive development, areas of study cover a wide range from representation, memory, language, conceptual development, reasoning, problem solving, and also strategy development and use (Smelser & Baltes, 2001). However, cognitive functioning in mainstream psychology tends to apply to processes such as memory (sensory and primary memory, encoding, retrieval, and storage), attention, perception (visual), action, problem solving, imagery (mental and visual), language (structuring and processing), motor control, as well as decision making and deductive reasoning (Willingham, 2007). Currently, all these areas of cognition exist as separate forms of studies and are not held together by a single theory as there is little communication in terms of interaction studies. This study investigated only a small area of the entire scope of cognition, which is short-term memory, spatial abilities (perception memory) and attention demanding abilities.

Cognitive abilities rise steeply from infancy to young adulthood and then are either maintained or decline to old age, depending on the specific ability (Craik & Bialystok, 2006). As shown in Figure 2.1, there exists vulnerability in youth and old age that is not present in the middle of life. Learning and remembering are essential to an individual's survival, and lifespan changes in these abilities depend greatly on brain plasticity, the growth and decline of brain matter and nervous system. In children, very rapid and competent learning seen in infants and children is a function of differential cell loss and synaptic growth which in combination with white matter

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