

## Systematic Review of PubMed Articles Prior to 2023 on Effects of Breakfast on School Performance

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### Abstract

Breakfast has been touted as the most important meal of the day, especially for school-aged individuals who requires energy and nutrients to support activities in school. However, the effects of breakfast on school performance have not been systematically reviewed. This study aims to fill this gap by conducting a systematic review on the effects of breakfast on school performance using articles indexed in PubMed prior to 2023. 41 of the original 94 articles (43.6%) were included. Majority of the studies have concluded that regular breakfast allows students to perform better in school; hence, skipping breakfast, especially prolonged skipping of meals, is not encouraged for school-aged individuals as it may lead to impaired cognitive function required for education.

### Introduction

Breakfast is the first meal and is often deemed as the most important meal of the day. Without breakfast, a person would not have adequate energy to start a day. Thus, parents would often instruct their children to eat breakfast before starting their day in school. A study has concluded that female students in senior grades who are socioeconomically disadvantaged are more prevalent in skipping breakfast [1]. To promote breakfast eating, schools usually provide free breakfast or breakfasts at affordable rates for students in school. They are often held in the classroom, during curriculum hours or in the school's cafeteria, before they start their first lesson [2].

What people eat for breakfast varies from country to country. In Western countries such as the United Kingdom (UK), their breakfast usually covers all essential nutrients required. Besides, colours presented are considered as well, providing consumers especially children an appealing appearance [3]. However, in Asian countries, breakfast is usually quick and easy food. There is not much consideration for the colours and nutrients present in the food. Therefore, their breakfast is usually considered based on the preparation time and difficulty level. It is also common to see people purchase breakfast [4].

Country status is also one of the points of consideration for such a topic as it reflects the country's current status economically. This benefits the study as it reflects the city's economic status indirectly as well [5]. For example, there are more selections and varieties available in developed or developing countries compared to undeveloped countries due to their countries' economic status. Hence,

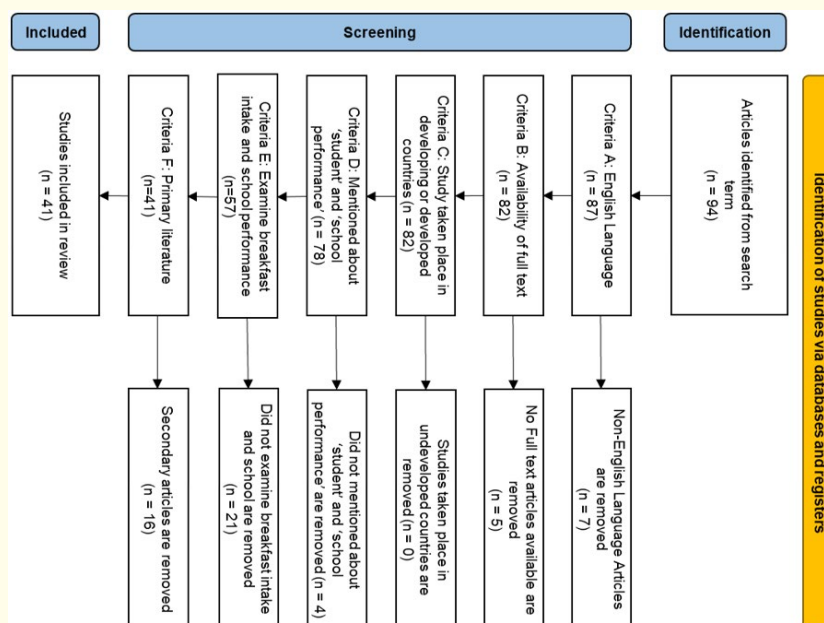
students living in these countries can also get their basic needs met more easily than others. Therefore, this study aims to investigate breakfast and its effect on school performance in students of different age groups.

## Methods

To source relevant articles, a search was done on 10 February 2023 for publications prior to 2023, using PubMed as the search engine. The search term used for this study is breakfast[tiab] AND student\*[tiab] AND performance[tiab]<sup>1</sup>, which means the terms, breakfast students and performance have to appear in the title or abstract at the same time. The inclusion criteria used for this study are as follows: (1) English language articles, (2) availability of full-text articles, (3) studies conducted in developing or developed countries, (4) mention of keywords 'students' and 'school performance', (5) examine breakfast intake and school performance, and (6) primary literature. The list of developing or developed countries for inclusion criteria #3 was determined from the World Bank Organization, which classify the world's economies based on the gross national income (GNI) per capita of the respective countries [6] where with a GNI less than \$1,025 are classified as undeveloped countries [5], which will be excluded from this study. Key observations from the included articles were primarily extracted by the first author, and verified by other co-authors for consistency.

## Results and Discussion

94 articles were identified using the search term (Figure 1). Among these 94 articles, 87 of the articles are in English (Criteria A), with 82 of them having full-text articles available (Criteria B) and conducted in developing or developed countries (Criteria C). Out of the 82 articles, 78 of them mentioned 'student' and 'school performance' (Criteria D). Among these 78 articles, 57 articles examine breakfast intake and school performance (Criteria E). Finally, 41 of them are primary literature (Criteria F). This brings the total of 41 articles to be included in this review.

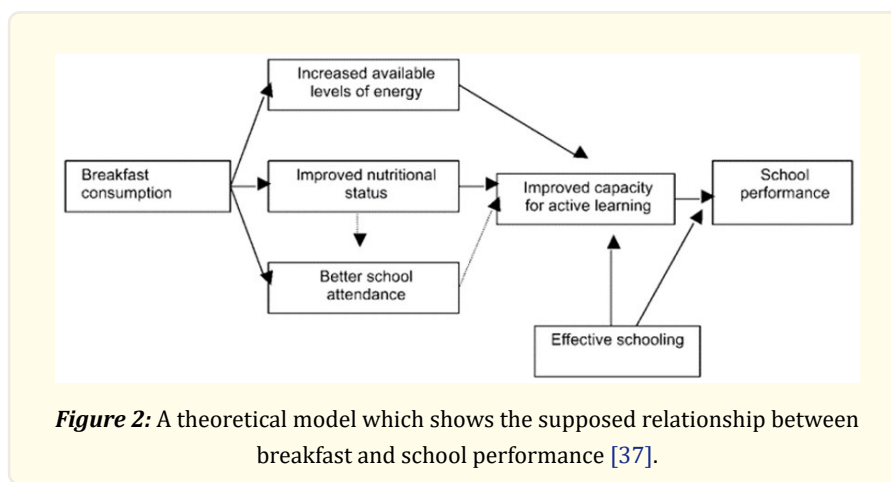


**Figure 1:** Flow diagram through the various criteria following PRISMA.

<sup>1</sup>[https://pubmed.ncbi.nlm.nih.gov/?term=breakfast\[tiab\]+AND+student\\*\[tiab\]+AND+performance\[tiab\]&filter=dates.1000/1/1-2023/1/1](https://pubmed.ncbi.nlm.nih.gov/?term=breakfast[tiab]+AND+student*[tiab]+AND+performance[tiab]&filter=dates.1000/1/1-2023/1/1)

Number	Theme	References
1	Effects on Elementary School Students	13 articles [7-19]
2	Effects on Middle School Students	3 articles [20-22]
3	Effects on High School Students	6 articles [23-28]
4	Effects on University Students	7 articles [29-35]
5	Other factors	13 articles [36-48]

**Table 1:** Articles related to the respective themes.



Overall findings from the studies mostly suggest positive effects of the importance of regularity of breakfast in children is essential. Having breakfast can lead to increased energy available and improve nutritional status, this can help have a better attendance rate in school by reducing the dropout rates in school. The combination of all 3 benefits can lead to an improved capacity for active learning, leading to better school performance (Figure 2). However, this does not happen the same for the different age groups. Some of the studies contradicted this diagram and concluded that there is no relationship between both.

As of the current research now, there is limited mention of the different food types or diet that helps in improving or worsening school performance and is restricted to elementary school students [49, 50]. Foods choices made by these group of students are classified as healthy or unhealthy, producing a grey area as some food that are consumed may be otherwise classified. On top of that, there are also no clear indication of the food item that was used in the analysis, thus unable to conclude its actual findings.

### Theme 1: Effects in primary school students

Out of the 41 included articles, 13 of them mentioned the effects of having regular breakfast on elementary or primary school students aged 6-12 years old. The findings that were found supported the theoretical model of the relationship between breakfast and school performance as seen in Figure 2. In addition, all studies have mainly concluded that regular breakfast brings better performance in school as compared to irregular breakfast consumption. However, there is 1 study that concluded otherwise.

Before the Universal-free school breakfast program was implemented, 33% of students are at nutritional risk which leads to them having poor school performances. This includes poor attendance, punctuality, grades more behaviour problems. However, significant improvements have been seen after implementation. For instance, the absence rate of students reduced from 11.5 days to 6.5 days and grades have been improved by at least half a grade in Reading, Math, Social Studies, and Science. In addition, students are also less hungry and increased school participation [51]. Therefore, schools could launch such programmes to encourage breakfast consumption.

tion and prevent students from skipping or missing meals at a young age. The positive impact displayed through this study supports the theoretical model in Figure 2.

In the Asser region, healthy eating has been concluded to be essential for better school performance. The study concluded that 77.1% of students have excellent school performance due to regular consumption of breakfast and frequent intake of fruits, vegetables, and milk; which contributes to high school performance at different degrees. Whereas frequent consumption of unhealthy food items such as soft drinks, instant noodles, fast food and confections will contribute to low school performance [49]. Low school performance can include low attendance rate, grades and less participation in class or school activity.

Besides the Asser region, other countries also show similar findings specifically referring to educational-related outcomes. Consuming breakfast right before test or examination, strong and positive associations were observed in both factors. Regardless of the measures used, similar results have been seen as well with no intervention effects [50]. In China, similar results have been concluded for students with regular breakfast daily. These students specifically 31 points scored better in both academic and cognitive performance. Besides elementary school students, similar results are also found in middle school children. In the same study, skipping breakfast is also addressed and concluded that skipping breakfast is at high prevalence in students with better family backgrounds and male students [52].

On the other hand, unhealthy breakfast items, such as crisps and sweet snacks, do not seem to cause an effect on educational performance even when research size increases. In female students, taking food with a higher glycemic index can help to improve spatial and short-term memory. This shows that breakfast consisting of foods with a lower glycemic index may have a positive effect on students' cognitive functioning, health, school attendance and academic outcome due to the steady release of energy throughout the morning [50]. Such a conclusion is however not seen in university students. This may be due to the different analysis methods used. In most of those studies, there is no indication of what the test subject eats or drinks thus the same conclusion cannot be made.

In Canada, it is discovered that unhealthy lifestyle behaviour can harm performance in specific subjects such as English language Arts (ELA). They include behaviours such as poor diet quality, and inadequate physical activity. Whereas unhealthy lifestyle behaviour such as frequent skipping breakfast, and being physically inactive during morning breaks and after school shows poor performance in specific subjects, such as Mathematics [53].

Not only regular consumption of breakfast but the composition of your breakfast is also essential and would cause an impact on academic performance. Consumption of whole-grain food can aid in reading and math and the proportion of carbohydrates in kilocalories (kcal) can help in spelling standard scores. On the other hand, drinking fruit juice seems to not affect improving fluency and mathematics. As for spelling, there seemed to be no relationship with fruit juice consumption [54].

With equivalent backgrounds, students that have taken breakfast excel in all components of the test used to access educational outcomes and it is deemed that the serving size of whole grains can have a positive effect on test performance. This brings improved cognitive performance, better attention and memory over the morning, whereas, serving the size of fruit juice will bring about negative effects. The possible reason for positive effects includes decreased post-meal glycaemia and better maintenance of blood glucose levels with complex carbohydrates [54].

This result supports initiatives made by health authorities such as Health Promotion Board (HPB) in Singapore. HPB has been finding ways to encourage healthy eating in students. One of the methods is emphasising whole grain food consumption and limiting the intake of sugar from fruit juices by setting guidelines for canteen vendors in schools. Regular inspection is also conducted to ensure canteen vendors abide by these guidelines [55].

Students in this age group are encouraged to engage in physical activities. Students who have more nutritious food and engage in more physical activity and fitness have higher math scores whereas reading scores can be improved through consumption of fewer sweetened beverages and engaging in vigorous physical activity [56].

Moving on, breakfast time also plays a part in influencing school performance. In between learning sessions, the increase in glucose concentration can help improve students' cognitive function and memory. However, it seems that the performance between students having routine breakfast and students who did not have routine breakfast and studied for 1.5 hours to 2 hours are rather similar. In addition, in 10% of students who have food with a high Glycaemic index (GI), elevated blood glucose is not reported after 2 hours of lessons. Having meals 2 hours before the start of the test does not seem to have any improvement instead supplementation of food 30 minutes before the test shows improvement in scores [57].

Students that are underweight, malnourished and stunted perform poorer in tests and exams. Students undernourished do not seem to lead to learning failure instead it is the environmental problems that can affect the development of thought processes and nutrient intake that leads to growth and learning failure [58]. This is possible due to the food choices that were exposed to students in this age group. To make it quick, parents often opt for food deliveries or using processed food. As processed food contains high amounts of preservatives and salt, it brings inadequate nutrition to the student, thus leading to such consequences. In addition, students at an older age would also choose to eat out with their peers and due to peer pressure, it would also affect their food choices, thinking that they should follow what their friends do.

Obese students perform better than underweight students due to the test medium happens to be their mother tongue thus performing better. In addition, obese students did slightly poorer in other subjects. Thus, being obese does not seem to be an advantage whether it is nutritionally or academically.

Breastfeeding is recognised as the most nutritious source of nutrients and is often encouraged to adopt for newborn babies compared to formula milk. It is also a contributing factor in students' mental and psych development [58]. During the study, a piece of information obtained was most of the test subjects are being breastfed for more than 6 months, however, this does not seem to cause a positive impact on the performances in students instead students being breastfed for less than 6 months performed better. It is possible due to the number of other socio-cultural and environmental factors from home and school and intelligence. It is still unformidable that breastfeeding has protective effects against obesity risk [58]. Studies have shown that missing breakfast will cause the student to be unable to cover the recommended daily intake of vitamins and minerals. To determine a good quality of breakfast, the student has at least one serving of the 3 food groups required. However, only a small minority of students (1.6%) managed to accomplish that. In addition, possible reasons for missing breakfast were evaluated and 40% of the students claims that there was a lack of time therefore missing breakfast [59].

Regular students can help students to have healthier mental health. Students who have lower self-esteem appear to have unhealthy lifestyle behaviours such as eating supper and watching television, skipping breakfast and/or lunch. It is also common that students with lower self-esteem may have a worsen parental relationship and therefore less likely to eat family meals. Irregular meals are concluded to be one of the causes of lower self-esteem and similar association have been found in boys and girls [60]. With lower self-esteem, these students are less likely to open themselves and share their thoughts with their family members. As time flies, they do not like to eat alone thus choosing not to eat or choose to watch television while eating, as a source of entertainment, making themselves feel less lonely.

Sleep is a contributing factor to obesity development, general health development and academic performance. As an elementary school student, it is recommended to have 9-12 hours of sleep daily [61]. In addition, having adequate hours of sleep has been proven to obtain better grades in school. Students will also spend lesser hours watching television, playing games and having more regular meals. Thus to have better grades, students can adopt healthier behaviour such as adequate sleep and healthy body weight since a significant association is found between these 3 factors [59].

In contradiction to the above-mentioned findings, a study done by Tehran, Iran shows that there is no relation or association between academic grade level with nutritional status and breakfast habits. Instead, it shows a relation in its prevalence of obesity. For example, student A did not have breakfast for 6 days or less in a week, the prevalence of getting obese is 18%, which is higher than

approximately 5% of the people having breakfast 6 days a week. In addition to the contradiction, students that fall under the category of incomplete breakfast group score better than other students. This finding thus contradicts the initial finding that breakfast will help to improve school performance specifically academics, which is seen in Figure 2 [62].

Through these findings, it can be concluded that regular breakfast brings about benefits from all aspects from physical to psychological [49-54, 57, 58, 60-63]. At this age group, it seems that emphasising breakfast is essential as it helps students to either maintain or improve their performances in school. It is formidable that consumption brings a wide range of benefits however as of current research, there seems to be not much scientific explanations to explain these findings. Not just having breakfast but the food choices made at this age group plays an important role in their development. Healthy food items such as fruits, vegetables, milk and whole grain foods can help to improve school performance in schools. Whereas unhealthy food such as crisps and sweet snacks do not have any effect on students' performance. In addition, it is formidable that breastfeeding brings multiple benefits and nutrients for students, however, this does not imply that they will perform better in school or academically.

### *Theme 2: Effects on middle school students*

After elementary school, they will progress upward to middle school or also known as secondary school in some Asian countries. In this age group, they are recommended to increase their carbohydrate intake [64]. Among the 41 articles, only 3 articles talk about the effects of breakfast on middle school students [20-22].

Some of the studies show similar results in elementary students and middle school students [52]. A study that took place in South India has concluded that various lifestyle factors can influence students' academic performance. For example, students studying in public schools have poorer academic performance due to skipping breakfast and adopting poor lifestyle habits. Among these students, 80% of them can get access to tobacco and other substance used [20].

In private schools in South India, academic performance is associated with students' Body Mass Index (BMI), and only 20% of students can get access to tobacco. These reasons concluded that private school seems to be a better school for students [20]. In addition, students who score better usually have higher attendance rates and families with stable economic and better parental education levels. Students who can get their hands on tobacco are proven to have academic difficulties [64]. Physical activity although is a factor of lifestyle, there are however no significance associated with academic performance which is a contradicted conclusion from the previous theme [56].

During years of education, it is common to experience learning difficulties thus regular intake of certain food can help to better manage specific learning difficulties. A regular meal pattern and high consumption of fruits, allow students to better manage mathematical-related difficulties experienced. It is not encouraged for these students having frequently consume unhealthy food such as sweets, chocolates, or savoury snacks as these will cause alternative effects. Writing and reading difficulties can be managed by having regular breakfast and dinner [21].

Based on these results, it seems that having healthier food choices can help to better manage students' learning difficulties and increase academic achievement. These could help them improve mental health and cognitive skills such as concentration and memory. Whereas consuming more unhealthy food such as food that is high in added fats, sugar and salt can cause emotional behavioural problems in students. It also increases the chances of getting depression by 80% as compared to students eating healthily [65].

One of the limitations of these studies is firstly self-reported data. They thus bring biases as respondents would choose to neglect information. In addition, many studies are emphasising the positive side of having nutritious food and regular meals, however, there seems to be no explanation given to explain why this happens. After the outbreak of the pandemic, the use of technologies such as the Internet has become part of our life thus some classes are conducted through the use of the internet. This indirectly increases our screen time. Spending long hours on screen together with their dietary and lifestyle habits can also affect student's performance in school.



Male students consuming a wider range of healthier foods and beverage, engaged in vigorous physical activity but spend less time on screen and do not consume any sweetened beverages appears to score better in their math. Whereas female students engaged in moderate or vigorous physical activity, have less sweetened beverages and spend less time watching television have a higher reading score [22]. The increased intake of sweetened beverages and decreased intake of milk can increase their caloric intake and reduce their nutrient intake this would be associated with weight gain but there seems to be no association with academic performance [22]. This study focuses on the student's characteristics and most of the data are self-reported. This brings a certain level of biasedness and chances of inaccurate data given may be higher due to the different standards used as well. Therefore, it is concluded that the conclusion made may not be as applicable.

### *Theme 3: Effects on tertiary school students*

Upon completion of middle school, they will progress to tertiary school. At this stage, they are starting to be financially stable and have more food choices made available to them. Among the 41 articles, 6 articles are related to this theme.

Students at this age will start to be concerned about their appearance in front of people. For instance, Female students often went on a diet to maintain their body shape. Whereas male students, start to attend regular gym sessions for bodybuilding purposes. These personal lifestyle habits cause them to have different nutritional requirements.

It is mentioned that female students will often go on diets to maintain their body shape. This is unnecessary as research has shown that with regular breakfast there will be no increase in the individual's BMI, which indirectly means that their weight would not have much change. The control group of that study shows a high increase in BMI [23]. Research studies have found that regularity of breakfast has greater odds of higher school connectedness and academic performance than those who did not. This implies that they are much more connected to school and perform academically better regardless of their level of education [27].

With the increasing number of students skipping breakfast at this age, it is proven that regular breakfast consumption can help to improve short-term memory and mood. However, it does not benefit adolescents' sustained attention. Overall breakfast did not cause much effect on the total memory score of the study population instead there are clear observations seen in specifically visuospatial memory in boys. Regular breakfast consumption has also shown positive effects on mood, receiving information and the alertness of students [28].

The Mediterranean diet is a diet that focuses on healthy eating. The Mediterranean diet, emphasizes daily wholegrain food consumption, fresh fruits, vegetable, nuts and low-fat dairy products. Their primary source of fats has to come from olive oil. On occasion, lean cuts of red meat and moderate alcohol intake such as red wine can be included as part of the diet [25, 66]. It has also been proven to reduce the risk of obesity, cardiovascular disease and diabetes.

Students at this age may come in contact to understand the diet and with initial understanding, they may even try to adopt such diet due to the various benefits and own appearance outcome. In Lebanese high school students, the overall adherence to such a diet is 43%, which is considered as low with girls having a higher adherence compared to boys. This could lead to an increase in the risk of obesity and having unhealthy breakfast options, or even skipping meals such as breakfast. Compared with students from private schools and older adolescents, younger adolescents, students from public schools and students with the highest grades have higher adherence to such diets [25].

Despite knowing the importance of breakfast, the attitude would at times make breakfast consumption difficult. At this stage of the study, students learn new scientific material and information, therefore they require good mental concentration during class. Thus, healthy and energizing breakfast is essential as it helps the students to have more energy and better concentration for the day. After long hours of fasting since the previous night, missing breakfast can reduce the brain's access to nutrients thus leading to reduced mental functioning. Nutritional-related diseases such as iron deficiency in girls can interrupt learning. One of the possible solutions to this regulating student's bedtime. This increases their interest in having breakfast. Students would also receive essential nutrients in

the right amount to concentrate in class [26].

In rural regions, adolescents missing breakfast for more than 3 days a week are noticed to have issues in eating breakfast provided by the school and thus they are most likely unable to report potential positive benefits of eating breakfast on their academic, social and overall health status [24]. Possible barriers identified include cost, food quality and sleep. Under the National Sleep Association, they are recommended to have 8 to 10 hours of sleep [67]; however, as of 2014, only 15% achieved 8.5 hours of sleep [67]. Students at this age would treat sleeping as the first task on hand; thus, neglect eating breakfast to obtain more sleep.

#### *Theme 4: Effects on university students*

After completing tertiary school, students progress to university. Nutritional requirements and concerns are similar when they are at the tertiary school stage. In the event, there is a change to their lifestyle or their nutritional requirements will change as well. In addition, their food choices would be based on several factors such as financial considerations, whether they are under a meal plan and the food choices that are available to them [33]. Among the 41 articles, 7 articles are related to this theme.

A study in 2019 concluded that breakfast consumption plays a significant role in the respective current Grade Point Average (GPA) in students. Current GPA refers to the GPA that students obtained for the individual semester. For instance, a student who had breakfast for 4 days a week has GPA close to the average. However, if the student has been taking breakfast for the past 7 days, their current GPA would be above average and vice versa. Other factors such as the amount of time spent on work or rest may post a greater influence on the grades as well [33].

Fast food is a common food option that university students will choose due to its quickness and convenience. The same study also concluded that students who have fast food at least 7 times a week would have a current GPA that is significantly lower than students who do not eat or eat less than 4 times in the same week [33]. In the event breakfast is skipped, it causes a distinguishable effect on students' appetite before lunchtime, and they are also more prone to consuming more energy-dense food. However, this is not seen in students who have taken breakfast in the morning [32]. Biochemically, plasma glucose and insulin level is lower when students have a high protein or low carbohydrate (HP/LC) breakfast in comparison to low protein or high carbohydrate without animal protein (LP/HC-NAP). In addition, exchanging protein with carbohydrates can lower the postprandial insulin and glucose response of the body.

Postprandial insulin is one of the biochemical factors used to analyse diabetes-related diseases. As of research in 2017, it is concluded that insulin resistance can lead to hyperinsulinemia due to the carbohydrate load and lead to a serious pathophysiological state. However, it is known that hyperinsulinemia usually results from a postprandial state [68]. It is also known as a fed state that happens after approximately 6-12 hours [69]. Fasting measures such as homeostatic model assessment (HOMA) are enough to predict postprandial hyperinsulinemia [69]. HOMA is a model that is calculated based on a computer. It deduces the plasma glucose and insulin concentrations from different levels of beta-cell deficiency and insulin resistance [68].

On top of that, students' mood seems to be affected and can be caused by the missing breakfast. the same study concluded that students who did not take breakfast appeared to be less happy but a statistically significant effect on mood and cognitive performance is not seen. Therefore, changes to the macronutrient content of breakfast such as switching carbohydrates with protein can affect the glycemic response in students but it does not affect the appetite or cognitive performance of the students [30].

From a psychological aspect, motivation plays an important role in improving school performance academically. There are 2 main types of motivations, intrinsic and extrinsic motivations [70]. Intrinsic motivation refers to the internal satisfaction obtained through completing an activity or task. This can be seen in young infants and adults through different tasks such as trying to throw, bite, play crosswords and make paintings. Whereas extrinsic motivation refers to completing a task for the reward that comes with it [71]. A study based on female university students concluded that there is a significant association between intrinsic motivation towards knowledge, accomplishments, and external regulation. In addition, detailed results have shown that students with a higher GPA are more likely to report eating breakfast and more servings of fruits and vegetables daily. To improve academic performance, it is recom-



mended to have higher intrinsic motivation and lower extrinsic motivation. Surprisingly, students who do not believe in the existence of gods fall under the higher GPA group [31].

Not only eating breakfast is essential but having a nutritious breakfast is important as well. Nutritional quality is essential as it prevents students from being malnourished. A study that took place in Mexico has proven that breakfast with poor nutritional quality may harm cognitive interference performance and this could increase the chances of having low nutritional quality food in other meals later in the day [72]. Cognitive interference is negative thoughts and is often regarded as unwelcome in an individual's life. This outcome would indirectly lead to weight gain and increased metabolic risk. With good quality of nutrition in breakfast, the time needed for word reading and interference is smaller, and the amount of time used to answer is shorter, which is not supported by any scientific evidence at the moment. It can be caused by poor nutritional quality, stress and exercise [72]. Although nutritional quality affects cognitive interference, there are however several arguments about this finding as it is inconsistent with other conclusions given by other similar studies. The inconsistency could be due to the different intervals that participants have from finishing eating breakfast to the collection of data [72].

In the western region, students who take regular breakfast have better memory, activeness, performance and ability to meet the required nutrient value for their academics. If students become malnourished, they may perform badly in class due to their poor nutritional status leading to poor activeness, memory and general performance in the morning [29]. Based on the study, approximately 36% of the students have regular breakfast. This is significantly lower than similar studies and the following reasons are concluded, Firstly is the busy academic environment that the students are in. Another possible factor is the limited access to the different eatery joints available to students [29]. Other personal factors such as financial status and family background will also influence their choices of having breakfast. This leads to missing breakfast and thus unable to meet nutritional needs. In the long run, it is proven that it will lead to students being inactive in class, poor concentration and poor memory [29]. An interesting finding from this same study is female students are more likely to have regular breakfast as compared to males, who are more likely to skip breakfast [35]. It is interesting as a survey shows that younger adults are a higher prevalence of being irregular breakfast consumers [35].

### **Theme 5: Other factors**

Generally speaking, other possible factors can cause an effect on school performance which can be seen in 12 articles out of the 41 selected articles. They include family background, socio-economic status and skipping breakfast. One of the possible factors is the student's family background. An analysis done in Korea found that the educational level of their parents plays an important role. If students in grades 5 and 8 have parents that are highly educated, this group of students will obtain a better GPA. However, this relationship is not obvious in students studying in grade 11. This can be improved through regular consumption of breakfast and lunch is important and positive results are seen in most groups [40].

Regular dinners seem to work best on students in grade 11 but not in grades 5 and 8 specifically boys. Whereas regular breakfast and lunch seem to work best on grade 5 and 8 students. abiding by this eating plan, students can increase their GPA by 0.15 - 0.28 than those who did not. However, with differed nutritional intake, it seems that it is positively and weakly associated with a small group of people [38].

Another possible factor is a student's socioeconomic status as it determines if students can get their basic needs met which includes usual daily expenses. Being in a poor socio-economically status increases the prevalence. This prevalence is significantly higher in girls than in boys. However, it is also reported that the prevalence rate is distributed unequally [38]. It was mentioned previously that regularity of breakfast helps in scoring better. This conclusion is however contradicted by Walker et al. [48] who concluded that there is no evidence showing an impact of breakfast in the classroom (BIC). However, they cannot reject the fact that better achievements are observed in schools with larger BIC coverage. In comparison, there seems to be no convincing evidence of the impact of BIC on academic performance [37, 48].

Living in a city area bring about many food choices to students these students tend to opt for these choices as it is fast and convenient. A study conducted has concluded that gaining weight, and unhealthy eating patterns are the most common problem found in students. This leads to healthy nutrition is one of the factors that affect students' school performance which may include educational achievements. In addition, this would lead to overweight in their adulthood. In current society most parents are working parents thus they may not have the time to judge or ensure that the food they eat is nutritious [41].

Another possible factor would be the presence of a school-based breakfast program. These programs encourage breakfast regularity, and it has been proven that this has beneficial effects on students' attendance, grades and psychosocial function. Such programs however produce inconsistent results. Therefore, ways to ensure consistent result needs to be obtained [45], if this is to be implemented.

Food choices made by each student individual also play a role in the effect of school performance It is noted that specific food consumption such as breakfast, fish or caffeine would deduce the study progress in adult distance education. Distance education is an education method popular among working adults as it allows them to study anytime, anywhere. Results from this analysis show that there are no relations between breakfast, fish or caffeine and learning performances [39]. However, another similar study has concluded that other food choices such as weekly salad consumption and daily breakfast seem to help in academic achievement. In addition, when the criteria of multiple health behaviour are been met, students would achieve better academically [36]. These results contradict the initial findings and findings from similar studies as the different age group of test subjects is used in these analyses. this could be due to the different age groups that were involved in the test, thus producing such an outcome. It was mentioned that such analyses are unable to ensure consistent results being achieved thus leading to different conclusions made.

Skipping breakfast is a common condition that happens in people of all gender and all age. As humans, our main energy source is glucose. The body requires glucose to function and start the day. Between dinner to breakfast the next day, which can be as long as 12 hours, our glycogen stores are low. Once glycogen storage is used up, the body would start to break down fatty acids to provide the body with the energy needed, however, without carbohydrates, fatty acids are only partially oxidized leading to reduced energy levels [73]. Hence, breakfast is important for the human body as it refills the glycogen storage which will break down into glucose supply to boost our energy level and alertness while at the same time providing other essential nutrients that we required. In addition, it also helps our body to maintain metabolism for the day. In the long term it is proven that in the short term, it can improve energy levels and the ability to concentrate in students. In the long term, it helps with better weight management and reduces chronic disease [73].

Breakfast also provides you with energy, essential vitamins, minerals and nutrients, control weight, boost brainpower and more. Skipping meals such as breakfast does not seem to have any noticeable effect on school performance such as alertness and tiredness during the day. Whereas in the long run, it may lead to other factors such as insufficient fruit and vegetable intake, and unhealthy lifestyle behaviour [44]. This would in turn lead to 9 indicators shown such as lower happiness, depression and sleeping issues and poor academic performances in university students. During the consumption of breakfast, carbohydrates are converted to glucose, essential for tryptophan formation, which can regulate depressive symptoms, irritable mood and cognitive function [46].

It is mentioned above that skipping breakfast would cause an effect on students' nutritional status, which may cause the occurrence of nutrition-related disease and poor school performance, which can include attendance, academic and concentration in students of all ages [29, 51, 53, 64, 72]. One possible reason could be due to the long hours of fasting, the brain has not received the energy or glucose to move on thus making some tasks feel harder than normal. Students would also experience fatigue more easily however, the mechanisms that are involved remain unknown [47].

Based on the current research there seems to be no articles mentioned about the pathology of people when breakfast is skipped. However, it is found that students who skip breakfast often are more prone to getting health concerns such as being obese and having metabolic disease, being nutritionally inadequate [73]. This eating behaviour can be common in adolescents [74].

10th - grade students, which is equivalent to secondary 4 in Singapore context, concluded that skipping breakfast is common in students at this age. Skipping breakfast can lead to implications such as mental distress and academic performance. This implication is stronger in Norwegians and/or boys than immigrants or girls [42].

Other prevalent population includes female students, later adolescence, poor family background which include lower socioeconomic status and single-parent families, sleep and students graduating from colleges [44]. Frequently skipping breakfast has also proven to lead to unhealthy lifestyles, poorer diets, reduced physical activity and spending an increased amount of time on television [38]. This could be due to the psychological mindset of body shape. Female students at this age would be concerned about their appearance leading them to miss breakfast, however, it is concluded that skipping breakfast is not an effective method for losing weight. It will often lead to higher caloric intake later in the day, leading to weight gain in the long run [24].

Skipping breakfast would also result in more snacking between meals thus leading to lower micronutrient intake. Compared with someone who has a regular breakfast, they will consume more alcohol, sucrose and lesser micronutrient [24]. With other social variables included, older students and students studying a lower grade also have a higher prevalence of skipping breakfast. Through the study, there seems to be an indirect connection between migratory status as there is a higher prevalence rate of skipping breakfast found in first and second-migrant girls as compared to natives. Students of low socioeconomic status have a 28% to 30% risk of skipping breakfast daily as compared to those of higher socioeconomic status [38]. This finding however contradicts the previous finding that male students with better family backgrounds are at higher prevalence in skipping breakfast. This could be due to the different sample population that was used in both studies. The sample population came from 2 different countries, China and Spain. These countries are at both ends of the world map. Thus, this brings cultural differences into factor.

In addition, both studies use different analysis methods to deduce and obtain the results established. The difference in analysis methods can also bring about different conclusions, thus showing contradicting results as well. An interesting finding is eating habits and behaviours in France seem to be very different from Asian and Western countries. In France, approximately 84% of the student have breakfast almost every day and most of them are female students, which is contradictory to the common myth. In addition, food choices made by students are highly nutritious as they consist of food such as bread with jam or butter spreads and milk [43].

To improve such conditions there are many quick, easy and healthy recipes available online. Some of these foods include oat porridge, wholegrain cereal, fresh fruits and nuts and smoothies. Since they are all quick and easy recipes, individuals can prepare and have them before getting started on their daily tasks [73].

### *Limitations of this study*

The articles that fall under these theme uses different ways to test students' educational outcome or to use it to compare against the other data collect [45, 49]. This test includes Statutory Assessment Test (SAT), Raven's test and Wechsler Individual Achievement Test (WIAT-III) [50, 54, 58]. Besides these tests, some of these educational outcomes are self-reported data by the participants of the test. This serves as a limitation as this brings inaccuracy to the results obtained due to the different standards of each test and self-reported data providing biases to the results obtained.

Not only educational outcome, other factors used to assess school performance such as attendance and concentration also uses different methods to obtain the results. This also serves as a limitation as most of the articles included did not mentioned how is school performance assessed or what are the standards that was used to assess that, bringing limitation to this review.

Another limitation is the widely ranged age group in different studies. As a usual high school student, they are around 15-18 years old. The selected articles however have age groups that are wider than the supposed range, leading to combined results in some of the articles. In addition, the specific type of food and its relations seems to be not found in this age group. Therefore, this could be one of the possible future research topics.

As of current research, it was not mentioned about this intervention in undeveloped countries, where their GNI is less than \$1,025. This shows that there is no related research done at the moment. Not only undeveloped countries, there seems to be no related studies conducted neither in Singapore nor the schools though it is a developed country. Thus, this may also be possible of how breakfast is essential in the current society in Singapore settings.

## Conclusion

Majority of the studies have concluded that regular breakfast allows students to perform better in school and there is a minority of the studies concluded that regular breakfast does not affect the students. There are various conclusions made but there does not seem to have a scientific explanation to these conclusions. In addition, these conclusions are made based on the respective countries thus not all information applies to others due to the different culture and food choices available. Skipping breakfast is an action that is not encouraged although it can happen in students of all ages and statuses. Prolonged skipping of meals, can lead to loss of essential nutrition and impaired cognitive functioning. Through this review, it is recommended to have breakfast before starting the day as it gives the energy that is required by the body. Future research could be about explaining the possible pathology of skipping meals in the human body based on the different food types or diets that would improve or worsen school performance.

## Supplementary Materials

Data files for this study can be downloaded at [https://bit.ly/Breakfast\\_SchoolPerformance](https://bit.ly/Breakfast_SchoolPerformance).

## Conflict of Interest

The authors declare no conflict of interest.

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