



The effectiveness of breakfast time on cognitive function among university students: A cluster experiment study protocol

Keefektifan waktu sarapan terhadap fungsi kognitif mahasiswa: Protokol studi eksperimen berbasis klaster

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Article History:

Received: January 13, 2025; Revised: February 19, 2025; Accepted: August 08, 2025; Published: September 8, 2025.

Publisher:



Politeknik Kesehatan Aceh
Kementerian Kesehatan RI

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Abstract

Breakfast is important for supporting cognitive function. However, national surveys show that around 56% of university students in Indonesia often skip breakfast. Research on the optimal timing of breakfast to enhance cognitive function is limited. This study aims to evaluate the effectiveness of different breakfast times on students' cognitive abilities and health indicators. A Cluster Randomized Controlled Trial (CRCT) was conducted at the University of Muhammadiyah Aceh in 2024. A total of 60 students from three faculties were recruited and randomly assigned into three groups: intervention 1 (breakfast at 06:30–07:30), intervention 2 (07:31–08:31), and a control group (usual breakfast habits). The intervention lasted 8 weeks (4 weeks intervention, 4 weeks maintenance). Cognitive function was assessed using the Army Alpha Test, and mood was measured with the Profile of Mood Scales. Data were analyzed based on the Intention-to-Treat (ITT) principle and the Generalized Estimating Equation (GEE) method in SPSS version 25.0. Results: This protocol is designed to explore the most suitable breakfast timing for students. Expected outcomes include identifying breakfast times that significantly enhance cognitive function. In conclusion, the study is expected to provide evidence for designing breakfast interventions that support students' cognitive function and overall health.

Keywords: Breakfast timing, cognitive ability, student health

Abstrak

Sarapan berperan penting dalam mendukung fungsi kognitif. Namun, survei nasional menunjukkan bahwa sekitar 56% mahasiswa di Indonesia sering melewatkan sarapan. Penelitian tentang waktu sarapan yang optimal untuk mendukung fungsi kognitif masih terbatas. Studi ini bertujuan mengevaluasi efektivitas berbagai waktu sarapan terhadap kemampuan kognitif dan indikator kesehatan mahasiswa. Penelitian ini menggunakan desain *Cluster Randomized Controlled Trial* (CRCT) yang dilakukan di Universitas Muhammadiyah Aceh pada tahun 2024. Sebanyak 60 mahasiswa dari tiga fakultas direkrut dan dibagi secara acak menjadi tiga kelompok: intervensi 1 (sarapan pukul 06.30–07.30), intervensi 2 (07.31–08.31), dan kontrol (sarapan sesuai kebiasaan). Intervensi berlangsung selama 8 minggu (4 minggu intervensi, 4 minggu pemeliharaan). Fungsi kognitif diukur dengan *Army Alpha Test* dan *mood* diukur dengan *Profile of Mood Scales*. Data dianalisis berdasarkan prinsip *Intention-to-Treat* (ITT) menggunakan metode *Generalized Estimating Equation* (GEE) pada SPSS versi 25.0. Protokol ini dirancang untuk mengeksplorasi waktu sarapan paling tepat bagi mahasiswa. Hasil yang diharapkan adalah identifikasi waktu sarapan yang secara signifikan meningkatkan fungsi kognitif. Penelitian ini diharapkan dapat memberikan informasi untuk merancang strategi intervensi sarapan yang mendukung fungsi kognitif dan kesehatan mahasiswa.

Kata Kunci: Kesehatan mahasiswa, kemampuan kognitif, waktu sarapan

Introduction

Breakfast is crucial for every individual to begin daily activities. The benefits of regular breakfast include maintaining blood glucose levels, which serve as an energy source in the body and are utilized to enhance cognitive function and concentration (Moreno-Aznar et al., 2021). According to Benton, the rise in blood glucose levels after breakfast supports neurotransmitter activities, such as acetylcholine, serotonin, and noradrenaline, which play an essential role in memory consolidation, modulation, motivation, and attention (Ruixue et al., 2024). A study conducted in Korea demonstrated that students with irregular breakfast habits tend to have higher fasting insulin levels than those with regular breakfast habits (Kim et al., 2022). Furthermore, skipping breakfast has been shown to significantly impair cognitive performance in school-aged children (Moller et al., 2021), as well as in adults (Ishizuka et al., 2023).

Proper breakfast stimulates brain activity, thereby enhancing concentration for learning and facilitating knowledge absorption (Crabtree et al., 2022). A decline in concentration due to skipping breakfast in the long term can reduce academic performance (Dalgaard et al. 2023). Nevertheless, not all individuals in Indonesia practice the habit of starting a day with breakfast.

The Total Diet Survey (SDT) in 2014 conducted by the Health Research and Development Agency (Badan Penelitian dan Pengembangan Kesehatan), Ministry of Health of the Republic of Indonesia, in 2020, showed that 66,8% of children aged 6–12 years consumed breakfast with poor nutritional quality, and 47,7% of children did not meet the minimum energy requirement at breakfast (Ekaptiningrum, 2022). Moreover, the breakfast quality of some students in Indonesia has not fulfilled daily nutritional intake requirements, such as carbohydrates, protein, fat, and micronutrients (Putra et al., 2018).

Previous research has shown that as many as 56% of university students in Indonesia had infrequent breakfast habits because they were in a hurry to attend morning classes, leaving them unable to allocate time for breakfast. Other reasons identified included waking up late and thus missing breakfast, not being accustomed to having breakfast, experiencing stomach discomfort when eating breakfast, laziness, being busy with work, and a lack of preference

for available food, all of which are significant factors for skipping breakfast (Xian et al., 2018; Xian et al., 2023). Studies have also indicated that breakfast timing varies across individuals, with some not consuming breakfast (Kim et al. 2022).

Many studies have demonstrated that breakfast plays an important role in cognitive function in children, adolescents, and university students (Carew et al., 2022; Putra et al., 2018; Xian et al., 2023). However, most of these studies were conducted in developed countries or major provinces of Indonesia, and few have specifically evaluated the impact of breakfast timing variations on cognitive function. The eating window, defined as the interval between the first and last meal of the day, is part of a meal timing strategy that can influence body metabolism (Manoogian et al., 2019; Popp et al., 2021). In the context of breakfast, the timing of the first meal (for example, before 7 a.m. compared with after 9 a.m.) is thought to affect blood glucose stability and central nervous system activation, both of which are closely associated with focus and emotional regulation (Gletsu-Miller, 2019).

Although several previous studies have focused on the metabolic benefits of meal timing strategies such as intermittent fasting, similar principles can be applied to explore whether differences in breakfast timing influence health indicators and cognitive function (Manoogian et al., 2019; Popp et al., 2021; Zaman et al., 2023). Therefore, this study aimed to bridge this gap by examining the effects of breakfast timing variations on focus, mood, and physiological parameters among university students.

Numerous studies have investigated the effects of breakfast on the academic performance of children, adolescents, and university students in developed countries. However, research on the optimal timing of breakfast to enhance the cognitive abilities of university students remains limited. Indonesia, as a developing country, has Aceh as one of its provinces, which was recorded as the poorest province in 2022 (Agus, 2022). This condition may be influenced by the low quality of human resources, which could originate from inappropriate breakfast timing during education.

No specific study has yet been conducted on breakfast timing variations among university students in the Aceh Province. Therefore, investigating the effectiveness of breakfast timing in relation to cognitive function among

university students in Aceh, Indonesia is highly important. This study focused on evaluating the effectiveness of breakfast timing on cognitive abilities, without intervening in the composition of the food consumed. The findings of this study can later be generalized to all university students in Aceh, as the breakfast patterns of students at the University of Muhammadiyah Aceh are largely similar to those of students across the province. If proven effective, this study may serve as a reference for health policies in nutritional guidelines that specify optimal breakfast timing to improve cognitive performance among university students in Aceh Province.

This study specifically aimed to examine the effectiveness of appropriate variations in breakfast timing on the cognitive abilities of university students. Another objective was to evaluate the effect of appropriate breakfast timing variations on other health indicators, including systolic blood pressure, diastolic blood

pressure, heart rate, body weight, and calorie intake among university students.

Methods

Design

This study employed an experimental approach with a Cluster Randomized Controlled Trial (CRCT) design, using a non-blinded parallel group, by testing three groups that consumed breakfast at different times.

Conceptual Framework

This study refers to the theory of behavior change, namely the theory of planned behavior, which consists of subjective norms, attitudes, perceived behavior control, intention, and behavior changes as the outcome (Baharuddin et al., 2023; Kennedy et al., 2017). Figure 1 presents the conceptual framework of this study.

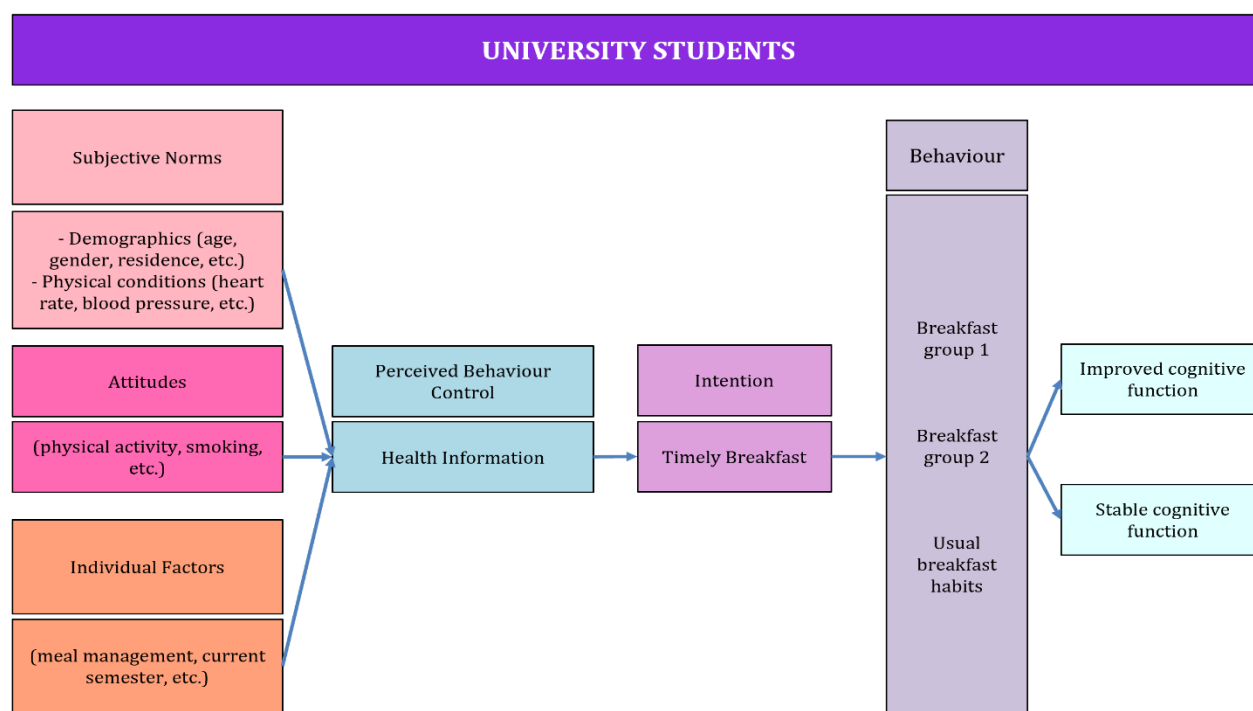


Figure 1. Conceptual framework of using the Theory of Planned Behaviour in breakfast and diet

Sample Calculation

The study population consisted of all active students in the 2023/2024 academic year. The sample size was calculated using G*Power 3,1,9,2 (Heinrich-Heine-Universität Düsseldorf, Germany) with the assumptions of an effect size of 0,25 (small to medium effect size (Cohen), a significance level of 5%, and a statistical power of 80%.

This effect size was chosen conservatively, considering that no previous study has specifically

evaluated the impact of variations in breakfast timing on cognitive function among university students. This approach aimed to minimize the risk of underpower and ensure sufficient ability to detect differences between groups within the CRCT design (Cohen, 2013). The calculation resulted in a total required sample size of 45 participants (15 participants per cluster). Taking into account the potential loss to follow-up, this study considered a 60% attrition risk; therefore,

the final sample size included 25 participants per cluster, consisting of 25 participants in intervention group 1, 25 participants in intervention group 2, and 25 participants in the control group.

Participant Recruitment, Randomization, and Allocation

This study recruited active students from the University of Muhammadiyah Aceh. The inclusion criteria were active enrollment in the 2023/2024 academic year, absence of ongoing medical treatment for any disease, and willingness to provide informed consent. The exclusion criteria included students with disorders affecting cognitive function or eating patterns, such as a history of neurological disorders, severe psychiatric conditions, or chronic medical illnesses, as well as students currently taking long-term medication.

The allocation process followed randomization rules through manual drawing, in which seven faculty members were randomized, and three groups were selected. One faculty member was assigned to each group: 6373 (intervention 1), 7383 (intervention 2), and control. Blinding could not be applied in this study, as the researchers needed to be aware of the intervention group allocations to organize breakfast schedules according to the assigned intervention. In addition, outcome assessment blinding was not feasible because enumerators were required to interact directly with participants during data collection, including measurements of blood pressure, heart rate, and cognitive assessments. Nevertheless, enumerators received prior training and were not informed about the intervention groups to which the participants belonged, thereby maintaining objectivity in the data collection process.

Intervention Setting

This study will be conducted over eight weeks, consisting of four weeks of intervention and four weeks of maintenance. All groups (Intervention 1, Intervention 2, and control) were instructed to wake up at 06:00. Intervention Group 1 will have breakfast between 06:30 and 07:30 and lunch between 12:00 and 13:00 each day. Intervention group 2 will have breakfast between 07:31 and 08:31 and lunch between 12:00 and 13:00 each day. The control group will have breakfast and lunch, as usual.

All groups will receive an educational session on balanced meal portions using the “Isi Piringku” (My Plate) flyer introduced by the Indonesian Ministry of Health (2018). The “Isi Piringku” education will be provided to all participants prior to the intervention to ensure a uniform understanding across groups regarding balanced daily meal portions. The education will be delivered through a brief face-to-face session with verbal explanations, accompanied by visual displays of the “Isi Piringku” image. This image will serve as a visual aid to clarify the recommended portion sizes and types of food according to the balanced nutrition guidelines. It will not be part of the main intervention but rather an effort to reduce informational bias between groups.

The type of food consumed will not be the focus of the intervention, as this study emphasizes variations in breakfast timing. Nevertheless, total caloric intake will still be analyzed using the NutriSurvey application to monitor general nutritional quality and maintain the homogeneity of energy intake among participants.

All participants will be provided with written and verbal instructions to avoid changing their sleep habits or physical activities during the intervention and maintenance periods. This step was intended to maintain the homogeneity of external factors that may influence outcomes and minimize bias.

Assessment

All participants will be assessed before the intervention, in the fourth week after the intervention, and in the eighth week after the self-maintenance phase using self-report instruments and measurements conducted by healthcare personnel.

Cognitive functions include focus and mood. The focus will be assessed using the Army Alpha Test, which is recognized as an effective questionnaire consisting of 12 items (Pujiastuti et al., 2024). Mood will be assessed using the Indonesian Profile of Mood Scale (PoMS), which consists of 64 questions divided into six sub-moods: tension, anxiety, depression, irritability, anger-hostility, vigor-activity, and fatigue-confusion (Prahastini et al., 2020).

Blood pressure and heart rate were measured using a calibrated Omron sphygmomanometer (Omron HEM 7130 LP; Kyoto, Japan) (Baharuddin et al., 2023). Body

weight was measured using a digital scale (Family Dr. Oserio FEP-103, Taichung, Taiwan) (Baharuddin et al., 2023).

Calorie intake during the study will be measured using the NutriSurvey application, a tool for calculating participants' micronutrient and macronutrient consumption (Damayanti et al., 2021). Dietary records during the study will be collected using a 3-day food record in which participants log the types of foods consumed. Participants will complete this form for three days at baseline before the intervention begins, three days during the intervention, and three days during the maintenance phase (Baharuddin et al., 2023). The recorded information will then be entered into the NutriSurvey application to estimate the participants' total caloric intake. To control for the risk of self-reporting bias, each participant will be given an example of how to complete the 3-day food record and will be reminded to fill in the form immediately after eating.

Participant data will be stored in a locked cabinet by the principal investigator who will have exclusive access to the data, including signed informed consent forms. The research team will be trained in data confidentiality prior to the intervention; therefore, registration data will be coded after screening.

Compliance

During the intervention phase, participants from groups 6373 and 7383 were reminded to wake up and eat breakfast on time according to the intervention rules, and all groups were reminded to consume a balanced breakfast every day. This information was delivered individually through WhatsApp messages. All participants will also be reminded to complete the 3-day food record provided to them.

However, during the maintenance phase, the participants were free to manage their own breakfast and food consumption based on their own preferences. Participants were also allowed to contact the researchers via mobile phone if they wished to consult or if they experienced any adverse effects.

Adverse Events

Participation in the study was voluntary. All participants were informed that previous breakfast studies did not have any negative effects on them.

However, if participants experience illness or discomfort during this study, they will be referred to the nearest health center, and they will be free to remain in or withdraw from the study. The research team will be prepared to address any adverse effects that may arise and will refer participants to the nearest hospital or clinic for treatment.

Statistical Analysis

This study followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guidelines in accordance with RCT implementation standards (Cuschieri, 2019). Descriptive analysis will describe the sociodemographic characteristics and health index outcomes in this study. Normality tests will be conducted for numerical data; normally distributed data will be presented as mean and standard deviation (SD), while non-normal data will be presented as median and interquartile range. Categorical data are presented as frequencies and percentages.

A paired t-test was used to evaluate changes before and after the intervention within each group. Meanwhile, to compare the effectiveness of the interventions among the three groups at multiple time points (pre-intervention, post-intervention, and post-maintenance), the Generalized Estimating Equation (GEE) method was used, as it can handle longitudinal data and account for intra-subject correlations in repeated measurements, making it suitable for this study design. For specific pairwise group comparisons, the Bonferroni post-hoc test was applied to control for type I errors due to multiple comparisons (Gans et al., 2022).

The analysis will be performed using the intention-to-treat (ITT) principle with the Last Observation Carried Forward (LOCF) approach to handle missing data. In this approach, the last available measurement from a participant was used to replace missing values due to study withdrawal (Leyrat et al., 2021; Wharton et al., 2021). All statistical analyses were performed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA).

This study was registered at clinicaltrials.gov, a database in the United States, with registration number NCT06541392. The study was also registered with the Ethics Committee of Politeknik Kesehatan Aceh,

Indonesia, under registration numbers DP.04.03/12.7/219/2024.

Result and Discussion

This study represents the first investigation of optimal breakfast timing among university students in Aceh and Indonesia (Barokah et al., 2022; Hatanaka et al., 2022; Najla et al., 2025). Missing data in this study will be analyzed using the intention-to-treat (ITT) approach with the Last Observation Carried Forward (LOCF) imputation method, where missing values will be replaced by the last available measurement (Ahn & Kang, 2023).

This study acknowledges that the use of LOCF has limitations, particularly if the proportion of missing data is substantial, which may affect the validity of the findings. To mitigate this, strict follow-up of all participants will be conducted, and the reasons for missing data will be systematically recorded. If missing data exceeds a significant threshold, multiple imputations with the LOCF method will be considered as an additional sensitivity analysis. The primary endpoint of this study was the improvement of focus and mood among students, while the secondary endpoints included stability of blood pressure, stability of heart rate, weight reduction, and daytime caloric intake in the intervention groups.

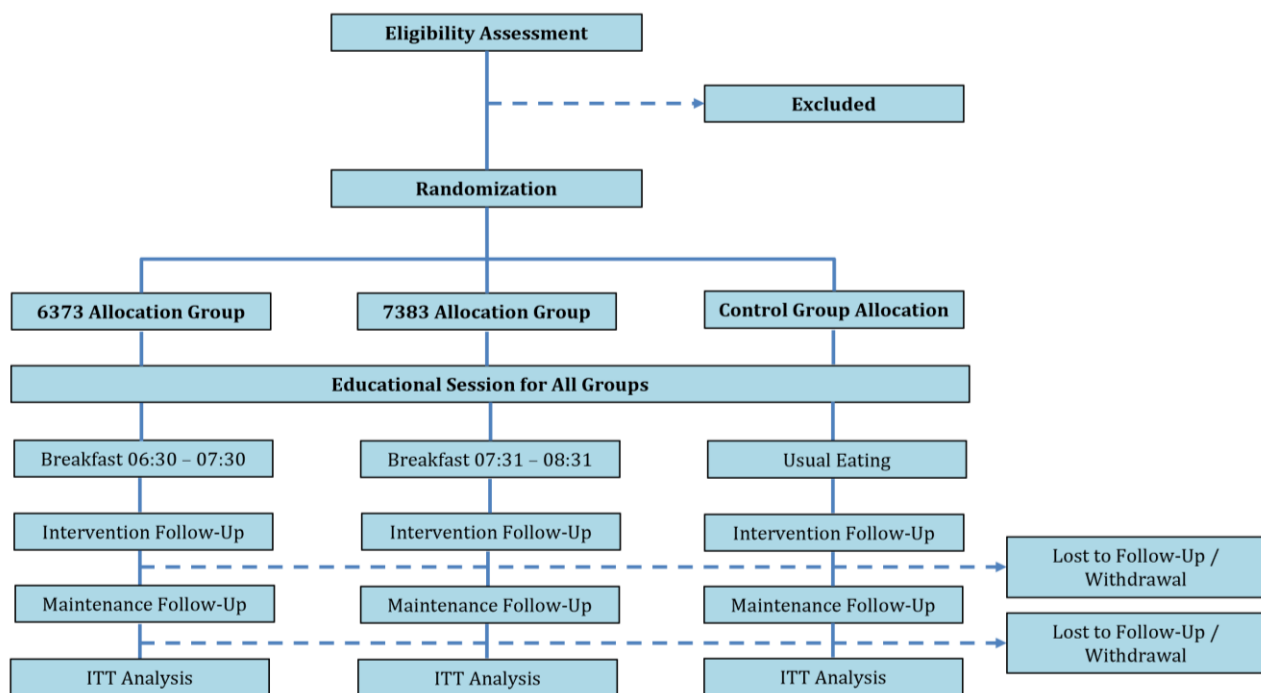


Figure 2. CONSORT 2010 Flowchart

The participant flow diagram follows the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Cuschieri, 2019). and are shown in Fig. 2. This diagram outlines the flow of recruitment, allocation, intervention, follow-up, and analysis, in accordance with the research plan. Although the present work is still a protocol and does not yet include actual data, the study projected potential dropouts at each intervention and maintenance phase. Missing data (dropouts) will be documented in detail at every stage, specifying the number of participants lost and, where available, the reasons for dropouts. This information will be

included in the final CONSORT diagram of the publication outcome.

All analyses will be reported with p-values, effect sizes, and confidence intervals to provide an accurate picture of the statistical significance and magnitude of the intervention effects. The data are also presented in informative tables and graphs to facilitate reader understanding. This presentation is expected to provide a clear and valid interpretation of the findings.

Poor mood and lack of focus may affect academic performance, while lifestyle factors, such as unhealthy diet, low physical activity,

stress, and fatigue may also play a role (Reynolds et al., 2023). One key component is breakfast habits, which help maintain stable blood glucose levels as the primary energy source for cognitive functions, including concentration and emotional regulation (Moreno-Aznar et al., 2021). Several studies have shown that low caloric intake at breakfast or skipping breakfast altogether may impair concentration and worsen mood (Crabtree et al., 2022; Dalgaard et al., 2023). Although a direct causal relationship cannot yet be firmly established, these findings support the importance of considering nutritious breakfast as a strategy to enhance academic performance and mental health among students.

Many students were reluctant or afraid to eat breakfast, with one common reason being the rush to attend early morning classes, leaving little time for breakfast. Other reasons include waking up late, lack of time due to early lectures, unfamiliarity with breakfast habits, stomach discomfort after eating breakfast, laziness, being busy with work, or simply disliking available food options (Xian et al., 2023). Numerous studies have demonstrated the benefits of breakfast on cognitive performance in children, adolescents, and university students, showing that lower breakfast caloric intake is associated with poorer cognitive abilities (Carew et al., 2022; Putra et al., 2018; Xian et al., 2023).

This study outlines a protocol for research on breakfast timing among university students. Furthermore, this study aimed to evaluate whether and how variations in breakfast timing may contribute to improved focus and mood, as well as reductions in body weight and energy intake in the intervention groups. The outcomes of this research will serve as a foundation for developing further interventions in future projects if the intervention is effective.

Although this study was conducted at a single university, the preliminary findings are expected to provide useful insights. Nevertheless, generalizing the results to the wider Indonesian student population will require careful consideration of diverse factors, such as socioeconomic status, local cultural practices, and food access, which will be further explored in subsequent studies.

The findings of this study can be disseminated to various stakeholders. For the scientific community, the results will be published in accredited national and international journals and presented at scientific conferences and panel discussions at both regional and national levels. In addition, the study outcomes will be summarized

in the form of a policy brief and delivered to the university, Health Department, and Ministry of Education as input for policies or programs aimed at improving students' cognitive function through proper breakfast timing. Advocacy efforts will also be pursued through strategic forums and cross-sector collaboration in Aceh and nationally.

Study Limitations

This study had several limitations. First, the absence of blinding may increase the risk of bias; however, this was minimized with objective and standardized measurement tools as well as training enumerators to follow strict measurement protocols. Second, confounding factors such as sleep quality, stress, and physical activity were not directly controlled. Nevertheless, the participants were advised not to alter their sleep patterns or physical activity levels during the intervention and maintenance phases. Third, because the study was conducted at a single university, the generalizability of the findings is limited. To address this, follow-up research with larger and more diverse samples across different regions is needed to test the consistency of the findings in various contexts.

Conclusion

This study evaluated the effects of breakfast timing on students' focus, mood, blood pressure, heart rate, body weight, and caloric intake. Preliminary findings suggest that early breakfast consumption tends to have positive effects on cognitive function and physical health. The complete results of this research are expected to provide a scientific basis for developing policies on optimal breakfast timing for university students, particularly in Aceh, with the potential for broader application at the national level.

The study also recommends that universities provide early breakfast services and adjust the timing of their early morning classes. The government should consider developing student nutrition guidelines based on meal timing. Meanwhile, students are encouraged to adopt the habit of early breakfast to support their concentration and health. Future research should involve a longer intervention period and consider other lifestyle factors such as physical activity and stress to achieve a more comprehensive understanding of the relationship between breakfast timing and student health. health monitoring programs for farmers to assess pesticide exposure and metabolic health.

Acknowledgments

We would like to express our deepest gratitude to the Ministry of Education, Culture, Research, and Technology for providing support and funding for this study. We also extend our sincere appreciation to the University of Muhammadiyah Aceh, particularly the Faculty of Economics, Faculty of Public Health, and Faculty of Psychology, for their invaluable support in the implementation of this research.

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