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Effect of Breakfast Skipping on Metabolism Among Adolescents

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Abstract: Breakfast skipping is increasingly common among adolescents, with prevalence rates ranging from 20 to 30% in developed countries. This review discusses the metabolic consequences of habitual breakfast omission during adolescence, which is an important period of growth and development. Current evidence suggests that breakfast skipping is associated with a number of detrimental changes in glucose homeostasis, lipid metabolism, energy expenditure, and hormonal function. Adolescents who regularly miss breakfast exhibit decreased insulin sensitivity, greater postprandial glucose excursions, and an unfavourable lipid profile. Furthermore, breakfast omission has been shown to disrupt metabolic circadian rhythms, contributing to increased obesity susceptibility via compensatory eating patterns and suppressed thermogenesis. The relationship between breakfast skipping and metabolic health is complex and multifactorial, with overall diet quality, physical activity level, sleep pattern, and genetic predisposition cited as important modulators of this association. This paper summarizes current research regarding breakfast skipping and its metabolic consequences in adolescents and highlights limitations in the current literature.

Keywords: *Breakfast Skipping, Adolescents, Metabolism, Insulin Resistance, Glucose Homeostasis, Lipid Metabolism.*

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I. INTRODUCTION

➢ *Background*

Adolescence is a critical period of growth and development associated with rapid physical changes, hormonal alterations, and the formation of lifelong habits that promote health. Nutrition at this age stage plays a key developmental role in supporting overall growth, cognitive function, and metabolic health. Among dietary behaviors, breakfast consumption has been widely investigated owing to its potential impact on daily nutritional intake and metabolic regulation.

Classically, breakfast is the first meal eaten after the overnight fast to break that long period without food intake and to start the metabolic processes of the day. Although breakfast has been considered an important meal by many health organizations around the world, this trend has gradually been changing, especially among adolescents. Epidemiological data from recent years show that approximately 20-30% of adolescents in Western countries skip breakfast regularly; this rate differs in various populations and socioeconomic groups.

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➢ *Prevalence and Determinants*

Factors contributing to breakfast skipping behaviour of adolescents are multiple. These include time constraints because of early school start times, lack of appetite in the morning, attempts at weight control, and absence of parental supervision during morning hours all have been identified as major determinants. Moreover, transition through adolescence is accompanied by increasing autonomy over food choices, which may be followed by less structured eating behaviour.

Within adolescence, the prevalence of breakfast skipping increases with age, with older adolescents more likely to miss breakfast than their younger counterparts. There are also gender differences, with some studies indicating that the prevalence among adolescent females is higher, in relation to weight control behaviours and body image concerns.

➢ *Rationale for Current Review*

Understanding the metabolic consequences of breakfast skipping is particularly important during adolescence for several reasons: first, adolescence represents a time of elevated metabolic demand because of growth and development; second, metabolic patterns and health behaviours established during adolescence tend to track into adulthood; third, the increasing prevalence of metabolic disorders, such as type 2 diabetes and metabolic syndrome, among youth requires the identification of modifiable risk factors. This review will comprehensively discuss the current evidence on the effects of breakfast skipping on various aspects of metabolism in adolescents.

II. METHODOLOGY

This narrative review presents a synthesis of peer-reviewed research published between 2000 and 2025 on breakfast skipping and metabolic outcomes in adolescents aged 10-19 years. Literature searches were carried out in databases such as PubMed, Web of Science, and Scopus. Keywords used for the literature search included "breakfast skipping," "breakfast omission," "metabolism," "adolescents," "teenagers," "insulin resistance," "glucose metabolism," and "lipid metabolism." All observational studies and intervention trials were included. Studies were selected based on relevance to metabolic outcomes, methodological quality, and contribution to the mechanisms underlying the breakfast-metabolism relationship.

III. GLUCOSE METABOLISM AND INSULIN SENSITIVITY

➢ *Acute Effects on Postprandial Glucose Response*

One of the most consistently documented metabolic consequences of breakfast skipping is altered postprandial glucose responses. Indeed, a number of experimental studies have shown that the omission of breakfast results in substantially higher glucose concentrations after lunch compared with days when breakfast is ingested. This "second meal effect" indicates that breakfast consumption has beneficial effects on glucose tolerance that extend to subsequent meals.

The mechanisms for impaired glucose tolerance due to omission of breakfast are multifactorial. Prolonged fasting beyond the overnight period may increase hepatic glucose output and decrease peripheral glucose uptake. Lack of the early morning insulin response that occurs after eating breakfast may also result in reduced insulin sensitivity for later meals.

One study by Betts et al. (2014), performed with continuous glucose monitoring, showed that healthy adults who omitted breakfast had greater glucose variability throughout the day, with significant postprandial hyperglycaemia after lunch and dinner. Although this study was performed in adults, similar patterns have been shown in adolescent populations; thus, the metabolic response to the omission of breakfast appears to emerge relatively early in life.

➢ *Insulin Resistance and Beta-Cell Function*

Chronic breakfast skipping has been linked to the markers of insulin resistance in adolescent populations. Several cross-sectional studies have reported that adolescents who consistently skip breakfast show higher fasting concentrations of insulin and higher values of HOMA-IR compared to those who regularly eat breakfast, even after adjustment for body mass index and levels of physical activity.

The association of breakfast skipping with insulin resistance may be bidirectional and influenced by adiposity. The omission of breakfast may contribute to greater caloric intake later in the day and preferential fat storage, increasing adiposity and subsequent insulin resistance. On the other hand, emerging insulin resistance may be associated with reduced morning appetite, creating a vicious circle that reinforces breakfast-skipping behaviour.

Intervention studies examining the effects of breakfast consumption in habitual breakfast-skippers have yielded mixed results. Some short-term trials have shown improvements in insulin sensitivity with regular breakfast consumption, while others have found no significant changes. These inconsistent findings may reflect the relatively short duration of most intervention studies and the complexity of factors influencing insulin sensitivity during adolescence.

➢ *Glycaemic Variability and Long-term Risk*

Besides mean glucose and insulin levels, the variability in blood glucose throughout the day, otherwise known as glycaemic variability, has also become an important metabolic parameter. Greater glycaemic variability has been related to increased oxidative stress, endothelial dysfunction, and cardiovascular risk. Skipping breakfast is seemingly associated with increased glycaemic variability, likely through a disrupted meal frequency and larger, less frequent meals.

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The long-term implications of breakfast skipping during adolescence for diabetes risk are still being actively investigated. Whereas short-term metabolic perturbations are well-documented, a limited number of prospective studies with adequate follow-up to assess diabetes incidence are available. Some cohort studies in adults have suggested that habitual breakfast skipping is associated with increased type 2 diabetes risk, but whether breakfast patterns established during adolescence independently predict future diabetes risk requires further study.

IV. LIPID METABOLISM

➢ *Fasting Lipid Profiles*

Several cross-sectional studies have also investigated the relations between breakfast consumption patterns and lipid profiles in adolescents. The majority of the evidence indicates that breakfast skippers tend to have a less favourable lipid profile, with higher total cholesterol, LDL cholesterol, and triglyceride concentrations and lower HDL cholesterol levels.

A large cross-sectional study of European adolescents, the HELENA study, showed that breakfast skippers had significantly higher total cholesterol and LDL-cholesterol concentrations than regular breakfast consumers, independent of body composition and other lifestyle factors. Similar associations have also been reported in diverse populations, including Asian and American adolescents.

The underlying mechanisms linking breakfast skipping to the adverse lipid profiles are not entirely clear. Compensatory overeating at later meals, especially with increased food intake of energy-dense, nutrient-poor foods, may help explain this. Also, there may be a factor of timing of nutrient intake that influences lipid metabolism through effects on circadian clock genes regulating lipid synthesis and catabolism.

➢ *Postprandial Lipemia*

Less attention has been devoted to postprandial lipid responses in relation to breakfast consumption. The few studies that have examined this question suggest that omission of breakfast may be associated with exaggerated postprandial triglyceride responses to subsequent meals. This finding parallels the observations regarding postprandial glucose responses and may reflect similar underlying mechanisms related to prolonged fasting and metabolic inflexibility.

Elevated postprandial lipemia is recognized as an independent cardiovascular risk factor, since it's associated with endothelial dysfunction, inflammation, and atherogenesis. If breakfast skipping chronically elevates postprandial triglyceride responses, this could represent a mechanism through which breakfast omission contributes to long-term cardiovascular risk.

V. ENERGY METABOLISM AND BODY COMPOSITION

➢ *Total Energy Intake and Diet Quality*

It is widely assumed that skipping breakfast reduces total daily energy intake and therefore could promote weight loss. However, evidence from adolescent populations does not as a rule support this hypothesis. While some studies reported a lower total energy intake among breakfast skippers, others found no difference or even higher daily energy intake compared to breakfast consumers.

The relationship between breakfast skipping and total energy intake is complex and influenced by multiple factors: compensation at later meals, different food choices, and individual metabolic responses to meal timing. Some studies indicate that breakfast skippers may compensate incompletely for the calories missed at breakfast, leading to a lower total intake, while others have larger portions at lunch and dinner or snack more, especially on energy-dense, nutrient-poor foods.

Beyond total energy intake, diet quality varies substantially across breakfast consumers and skippers. Adolescents who consume breakfast regularly have higher intakes of several key nutrients, such as fibre, calcium, folate, and vitamin C. Breakfast consumption is also associated with higher whole grain intake and lower consumption of added sugars and saturated fats throughout the day. These differences in overall dietary patterns may partly mediate some of the observed associations between skipping breakfast and metabolic outcomes.

➢ *Thermogenesis and Energy Expenditure*

The timing of food intake may impact on energy expenditure through effects on diet-induced thermogenesis, that is, the rise in energy expenditure following the consumption of food. Some studies indicate that DIT might be higher for meals ingested earlier in the day compared with identical meals consumed later, as a result of circadian variations in metabolic rate and sympathetic nervous system activity.

If breakfast consumption increases overall daily energy expenditure through improved thermogenesis, this may be one mechanism by which frequent breakfast eating maintains energy balance. However, studies examining 24-hour energy expenditure in relation to breakfast consumption have produced inconsistent results, with some showing higher expenditure among breakfast eaters and others finding no significant differences.

In most studies, acute omission of breakfast does not seem to affect the resting metabolic rate, which is the metabolic rate during the post-absorptive state. Chronic breakfast skipping could theoretically affect resting metabolic rate through changes in body composition, thyroid function, or adaptive thermogenesis, although evidence for such effects in adolescents is limited.

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➢ *Body Weight and Adiposity*

The relationship between breakfast consumption and body weight has been the subject of many studies. The majority of observational research has found an association between breakfast skipping and increased body mass index and higher risk of obesity in adolescents. These findings have been corroborated by various systematic reviews and meta-analyses. However, the magnitude of the effect observed is usually small.

However, causality remains uncertain. Reverse causation—a greater likelihood among overweight adolescents to skip breakfast as a weight control strategy—may account for the observed associations, and breakfast skipping may be a marker of other unhealthy lifestyle behaviours that combine to favor weight gain.

Generally, intervention studies that have assigned habitual breakfast skippers to consume breakfast have not reported consistent weight loss benefits, while some have observed even weight gain. These findings suggest that the relationship between breakfast consumption and body weight is more complex than simple observational associations suggest and may depend on individual characteristics, overall dietary patterns, and compensation mechanisms.

With respect to body composition, there is some evidence to suggest that breakfast skipping is associated with greater central adiposity independent of total body fatness. The distribution of central fat is of particular importance from a metabolic health standpoint, since visceral adipose tissue is metabolically active and exhibits strong associations with insulin resistance and cardiovascular risk.

VI. HORMONAL REGULATION

➢ *Appetite-Regulating Hormones*

Breakfast consumption affects the secretion and circulating levels of several appetite-regulating hormones. The orexigenic hormone ghrelin, which stimulates appetite, increases with fasting and is suppressed during eating. Several studies have reported that breakfast suppresses ghrelin strongly throughout the morning and may affect levels at later meals.

Both peptide YY and glucagon-like peptide-1 are anorexigenic hormones released from the gut in response to nutrient intake and have been shown to be elevated following breakfast consumption. These hormones promote satiety and may help regulate food intake at later meals. The absence of this hormonal response when breakfast is skipped could theoretically contribute to overeating later in the day.

Leptin, an adipokine that signals sufficient energy and suppresses appetite, exhibits circadian variation, tending to be low in the morning and higher in the evening. How meal timing interacts with circadian leptin rhythms, and how this might be changed by breakfast skipping, is not well understood.

➢ *Stress Hormones*

Cortisol follows a pronounced circadian rhythm, with levels peaking in the early morning (cortisol awakening response) and declining throughout the day. This morning cortisol surge has important metabolic effects, including increased hepatic glucose production and peripheral insulin resistance. The interaction between the cortisol awakening response and breakfast consumption represents an intriguing but understudied area.

Some studies suggest that breakfast ingestion may modulate the metabolic consequences of cortisol secretion during the morning, possibly through insulin secretion that opposes the hyperglycaemic influence of cortisol. Conversely, extended fasting may increase insulin resistance and gluconeogenesis in the face of persistently high morning cortisol.

There are limited data on the effects of habitual breakfast skipping on cortisol patterns in adolescents. Because adolescence is also a time of increased stress reactivity and continuing development of the HPA axis, a better understanding of how breakfast consumption interacts with the pattern of stress hormones requires further investigation.

VII. CIRCADIAN RHYTHMS AND CHRONO NUTRITION

➢ *Metabolic Circadian Rhythms*

Emerging research in chrono nutrition, or the study of how meal timing interacts with circadian biology, has provided new insights into the metabolic effects of breakfast consumption. Most metabolic processes, including glucose metabolism, lipid metabolism, and energy expenditure, show circadian rhythms controlled by molecular clock mechanisms present in virtually all cells.

Food timing provides a strong zeitgeber, which entrains peripheral circadian clocks in metabolic tissues, such as the liver, pancreas, adipose tissue, and muscle. Breakfast consumption may help align the peripheral clocks with the central circadian clock in the brain, promoting coherent metabolic function. In contrast, breakfast skipping may lead to misalignment of central and peripheral clocks.

This has been consistently shown in both animal and human studies: food intake is restricted to the active phase, producing better metabolic outcomes for the same number of total calories when compared to eating during the rest phase. These findings support the view that "when we eat" may be as important as "what we eat" for metabolic health.

➢ *Clock Genes and Metabolic Regulation*

At the molecular level, circadian rhythms are generated by transcriptional-translational feedback loops involving clock genes such as CLOCK, BMAL1, PER, and CRY. These clock genes regulate the expression of several metabolic genes involved in glucose metabolism, lipid metabolism, and mitochondrial function.

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The disruption of the circadian rhythm, whether by shift work, sleep deprivation, or irregular timing of food, has been linked to metabolic dysfunction, including obesity, insulin resistance, and dyslipidaemia. Although most studies involving circadian disruption have focused on either shift workers or animal models, it is likely that the basic principles apply to patterns of meal timing, including intake of breakfast.

During adolescence, the circadian preference (chronotype) often shifts toward eveningness, going to bed later and being less alert in the morning. This developmental change in circadian timing might contribute to reduced breakfast consumption and could represent a critical period when circadian misalignment and metabolic consequences of breakfast skipping are particularly relevant.

VIII. MODERATING FACTORS AND INDIVIDUAL VARIABILITY

➢ *Chronotype and Genetic Factors*

Individual responses to breakfast skipping appear to be highly variable, suggesting that genetic or constitutional factors may moderate the metabolic effects. Chronotype is one such moderating factor: it refers to the preference of an individual for morning or evening activity. "Morning types" or larks tend to consume breakfast more regularly and may experience more pronounced metabolic disturbances when breakfast is omitted compared to "evening types" or owls.

Genetic variations in clock genes, as well as genes involved in glucose and lipid metabolism, may influence both breakfast consumption behaviours and the metabolic response to meal timing. Polymorphisms in genes such as CLOCK, PER2, and MTNR1B have been associated with breakfast skipping behaviour, eating patterns, and metabolic traits; however, research among adolescent populations has been scarce.

➢ *Physical Activity and Sleep*

Another important moderating factor is physical activity. Physically active adolescents might be better at maintaining metabolic health in the face of breakfast skipping through enhanced insulin sensitivity and greater metabolic flexibility. Conversely, the combination of breakfast skipping and physical inactivity may be particularly detrimental.

Sleep duration and quality also interact with breakfast consumption patterns. Sleep deprivation is associated with altered appetite regulation, increased preference for energy-dense foods, and metabolic dysregulation. Adolescents often experience insufficient sleep due to biological shifts in circadian timing combined with early school start times. The combination of sleep deprivation and breakfast skipping may have synergistic adverse effects on metabolism.

➢ *Socioeconomic and Cultural Context*

Socioeconomic status influences breakfast consumption patterns, with lower SES adolescents more likely to skip breakfast. This may reflect food insecurity, lack of breakfast foods in the home, or competing time demands. The metabolic consequences of breakfast skipping may be more pronounced in lower SES populations where overall diet quality is poorer and stress levels are higher.

Breakfast consumption norms are also culturally framed. Whereas in some cultures, breakfast is a small, simple meal, in others, it constitutes the largest meal of the day. These cultural differences in the composition and timing of breakfast potentially impact the generalizability of research findings across populations.

IX. METHODOLOGICAL CONSIDERATIONS AND RESEARCH GAPS

➢ *Assessment Issues*

Studying the effects of breakfast consumption presents several methodological challenges. Defining what constitutes "breakfast" varies across studies, with some requiring a minimum caloric threshold while others accept any food or beverage consumed during morning hours. The timing window for breakfast also varies, typically ranging from wake-up to 10:00 AM or within 2 hours of waking.

Assessment of breakfast consumption generally depends on self-report, through dietary recalls, food frequency questionnaires, or food diaries. These are all subject to recall bias and social desirability bias, which may be heightened in adolescents sensitive about body image or concerned about peer perceptions. Misclassification of breakfast consumption status could attenuate observed associations.

Most studies assess breakfast consumption as a dichotomous variable (yes/no or eater/skipper) or categorize the usual frequency of consumption into categories (never, sometimes, daily), which may not capture important dimensions such as the timing of breakfast, composition, or size. The energy and macronutrient content of breakfast likely influences metabolic responses, yet this dimension is often not adequately captured.

➢ *Causality and Confounding*

Most of the studies on breakfast consumption in relation to metabolic outcomes in adolescents are observational and cross-sectional in nature. There are several aspects in which breakfast skippers differ from those who regularly eat breakfast besides the act of breakfast consumption per se: overall diet quality, physical activity, sleep patterns, socioeconomic status, and family structure. Although statistical adjustment may be used to account for measured confounders, residual confounding cannot be ruled out.

Another key consideration is that of reverse causation. Overweight or metabolically abnormal adolescents may be more likely to intentionally skip breakfast as one strategy to help lose weight, rather than the skipping of breakfast leading to metabolic dysfunction. Distinguishing between these directional relationships requires longitudinal data or intervention studies.

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There are few randomized controlled trials that have assigned participants to consume or skip breakfast for extended periods, and even fewer conducted in adolescent populations. The few existing trials have usually been of short duration, ranging from weeks to months, and often in small samples. Longer-term, adequately powered intervention studies are required to establish causality and quantify the magnitude of breakfast consumption effects on metabolic outcomes.

➢ *Future Research Directions*

Several important questions are incompletely addressed. First, the optimal composition and timing of breakfast to support metabolic health among adolescents is still unclear. Does the composition of macronutrients at breakfast (e.g., higher protein versus higher carbohydrate) affect metabolic responses? What is the relevance of breakfast timing relative to both wake time and clock time?

Second, the long-term metabolic effects of breakfast skipping behaviour set during adolescence should be determined in prospective studies with long follow-up periods into adulthood. Can adolescent breakfast behaviours predict adult metabolic disease risk regardless of adult behaviour?

Third, mechanisms underlying the relationship between breakfast consumption and metabolism require further elucidation. More studies utilizing continuous glucose monitoring, meal tolerance tests, and measures of hormonal and circadian regulation in adolescent populations would advance mechanistic understanding.

Fourth, studies of subgroups of adolescents at particular risk from adverse effects of skipping breakfast, or alternatively, who may not benefit from breakfast consumption, could inform personalized nutrition recommendations. The addition of chronotype and genetic variation measurements, along with other characteristics, may yield key effect modifiers.

Finally, intervention research, testing strategies that would increase breakfast consumption among adolescent breakfast skippers and evaluating whether such interventions improve metabolic outcomes, would yield useful practical guidance. Understanding barriers to breakfast consumption and developing feasible interventions tailored to adolescent lifestyles represents an important research priority.

X. CONCLUSIONS

Current evidence suggests that breakfast skipping is associated with several metabolic alterations in adolescents: impaired glucose tolerance, insulin resistance, unfavourable lipid profiles, and probably increased adiposity. Such mechanisms may involve a combination of factors including compensatory eating patterns, alterations in diet quality, disrupted circadian metabolic rhythms, and hormonal dysregulation.

The relation of breakfast to metabolic health is complex and draws on a multitude of interacting influences. Individual variability in response to breakfast omission is large, probably reflecting genetic background, chronotype, physical activity, sleep pattern, and overall lifestyle. Most prior studies have been observational, limiting causal inference, and results from intervention studies are inconsistent.

Given the available observational evidence and a generally better quality of diet among breakfast consumers, from the public health perspective, promotion of regular breakfast consumption among adolescents is still a reasonable recommendation. However, oversimplification of the message that "breakfast is the most important meal of the day" may not be appropriate for all individuals. More nuanced guidance considering breakfast composition, timing, and individual circumstances may be more effective.

Adolescence is a critical period for the establishment of lifelong patterns of eating and trajectories of metabolic health. Further studies on the metabolic effects of breakfast consumption patterns, identification of vulnerable subgroups, and effective interventions are needed. As research in chrono nutrition continues to evolve, one key future direction will be the integration of meal timing into nutritional guidance for adolescents.

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