

Review Article

The Interplay between Lifestyle Factors and Childhood Obesity: Existing Evidence and Future Research Directions

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Abstract

The level of childhood obesity continues to rise around the world, despite the use of many medical and behavioral interventions against weight gain, and the deployment of a number of significant public health initiatives. Existing interventions targeting obesity of school-age children have focused on nutrition and levels of physical activity are ineffective. Hence, innovative interventions and policies are needed to halt the obesity pandemic.

Substantial evidence shows that sleep deprivation reduces the level of physical activity, contributes to development of poor eating habits, and increases the extent of sedentary behavior, all of which increase the risk of obesity. However, the significance of chronic sleep insufficiency and its relationships with these risk factors for obesity is under-recognized. This relatively new research avenue is promising and needs to be further explored. Adopting a new approach that considers the interplay between sleep, physical activity, nutrition and screen time, affected by the 24/7 lifestyle of a society that consumes too much food and is relatively sleepless is expected to revolutionize existing approaches to prevention and treatment of childhood obesity.

Keywords

- Childhood obesity
- Physical activity
- Nutrition
- Sleep duration

INTRODUCTION

The level of childhood obesity continues to rise around the world, despite the use of many medical and behavioral interventions against weight gain, and the deployment of a number of significant public health initiatives. Existing interventions targeting obesity of school-age children have focused on nutrition and levels of physical activity are ineffective [1]. Hence, innovative interventions and policies are needed to halt the obesity pandemic. Substantial evidence shows that sleep deprivation reduces the level of physical activity, contributes to development of poor eating habits, and increases the extent of sedentary behavior, all of which increase the risk of obesity. However, the significance of chronic sleep insufficiency and its relationships with these risk factors for obesity is under-recognized. This relatively new research avenue is promising and needs to be further explored. The objective of this article is to describe the interplay between sleep, eating, and physical activity/sedentary behavior as they relate to childhood obesity based on studies conducted with children and to identify gaps and future research directions.

The Interplay between Sleep, Physical Activity, Nutrition and Screen-Time

Evidence supporting the associations between sleep deprivation and obesity: Epidemiological evidence indicates that short sleep duration is a risk factor for obesity [2, 3]. An inverse association between sleep duration and obesity has been observed in both cross-sectional [4-8] and longitudinal [9-14] studies of children and adolescents. Recently, it has been shown that, in comparison to children reporting 12-13 hours of sleep per night, the adjusted odds ratio for childhood overweight/obesity was 1.42 for those sleeping 10.5-11.5 hours and 3.45 for those sleeping 8-10 hours per night, even after adjustment for age, gender, and other risk factors [15]. In another study, short sleep duration was found to be a better predictor of overweight compared to other risk factors, including physical inactivity, extent of screen viewing, low familial income, low level of parental education, and parental obesity. In addition, preferential fat deposition in the abdominal area has been found in those who experience short sleep duration; in fact, short sleep duration was a better predictor of waist circumference than was the BMI value [16]. Acute studies in healthy young adults indicated

that restricting sleep to only 4 h/night for 6 nights increased cortisol levels and induced insulin resistance [17]. Other studies in healthy lean participants, with control of caloric intake and physical activity, identified an association between short sleep duration and increased insulin resistance, lower leptin level, elevated ghrelin concentration, and enhanced appetite [18]. More recently, similar hormonal changes were observed in large community-based studies in which 75% of subjects chronically slept for less than 8 hours/night [19]. Compared to a reference group reporting 8 hours of habitual sleep, those who usually slept for 5 hours a night had lower leptin and elevated ghrelin levels, independent of BMI value. Animal models of sleep deprivation revealed similar relationships between short sleep duration and weight gain, and implicate a broad range of potential autonomic, metabolic, and inflammatory mediators as important players in this process [20]. Similar mechanisms seem to play roles in other sleep disorders, such as sleep-disordered breathing [21]. Finally, sleep deprivation affects neural pathways relevant to self-control [22]. Impairments in such functioning may be related to loss of the ability to exert self-control and to demonstrate willpower when faced with tempting choices of calorie-rich food, and may increase the likelihood of impulsive food-choice decisions that lead to weight gain.

The interplay between sleep, physical activity/sedentary behavior and nutrition: Substantial evidence shows that sleep deprivation reduces the level of physical activity, contributes to development of poor eating habits, and increases the extent of sedentary behavior, all of which increase the risk of obesity. Sleep, Physical Activity, and Obesity. Lower levels of physical activity and reduced durations of habitual exercise in children are associated with a higher BMI [26], greater skin-fold thickness [26,27], elevated fat mass [28], and obesity [29,30]. Conversely, higher levels of physical activity and habitual exercise are associated with a decrease in BMI [31,32]. Sleep deprivation has been shown to affect the daytime levels of physical activity. Specifically, short sleep time decreases the amount of such physical activity, reduces the intensity of activity [33], and interferes with athletic performance [34]. Conversely, recent studies have shown that sleep extension not only increases the level of physical activity but also improves athletic performance [35]. In addition, regular vigorous exercise has been associated with improved sleep quality, shorter sleep onset latency, and fewer awakenings [36]. Hence, a complex and bidirectional association between physical activity and sleep is evident; sleep restriction leads to decreased physical activity and poor athletic performance, whereas sleep extension is associated with improved athletic performance and an increased level of physical activity helps to improve and extend sleep. Sleep, Nutrition and Obesity. Excess energy intake (relative to energy expenditure), and higher levels of fat and sugar ingestion by children, have been associated with a rise in the percentage of body fat [37], fat mass [38], increased skin fold thickness [39, 40], and increases in BMI [32]. Sleep deprivation has been associated with an increase in undesirable eating behavior, including rises in caloric intake and a preference for foods high in fat and sugar [14]. Experimental sleep studies have shown that acute sleep restriction caused a 22% increase in energy consumption in men sleeping for 4 h a night, compared to those sleeping 8

hours. The former participants were also hungrier both before dinner and breakfast [41]. Moderate sleep restriction has also been shown to lead to an increased consumption of snacks high in carbohydrate and fat content, especially between 19:00 and 07:00 [42], and alters energy balance in adolescents [43]. Sleep, Sedentary Behavior, and obesity. Sedentary habits are associated with a higher prevalence of overweight [30, 44-46], elevated BMI [26, 47, 48], and a greater skin-fold thickness [26, 48, 49]. These effects are often independent of levels of physical activity. Several relationships between the extent of screen viewing and sleep variables have been documented. It has been found that screen viewing was associated with less time spent in bed on week days [50]; delayed bedtimes on both weekdays and weekends [28, 51-54]; later wake-up times or out-of-bed times [28, 51, 52]; increased sleep onset latency [55,56]; shorter sleep duration [51-53, 55]; and development of sleep disorders involving bedtime resistance, sleep anxiety, and/or parasomnias [51, 55, 56]. Studies on primary school children found that 18-43% of such children had televisions in their bedrooms, 18-20% computers or video games, and 14% mobile phones [57]. It has been suggested that the linkage between increased use of electronic media and the rise in obesity is explained by the fact that interaction with such media in the bedroom shortens sleep, and that this sleep deprivation may affect metabolism in the manner outlined above [28]. The studies cited above have shown, first, that sleep deprivation is a significant, prevalent, neglected, risk factor for obesity; and, second, that sleep deprivation and all other key risk factors for obesity (reduced levels of physical activity, increased caloric intake, increased consumption of fat and sugar, and longer periods of screen viewing) are interrelated.

The impact of sleep extension on obesity prevention

Although the work cited above provides convincing evidence that sleep deprivation and risk for obesity interact, the evidence regarding the impact of extending sleep on the risk for obesity is mixed. For example, the work of Tremblay and Chaput clearly showed that total sleep time and sleep quality at baseline predicted loss of fat mass in adults who were overweight or obese and undergoing moderate caloric restriction, but stopped short of identifying the related mechanism [58]. Similarly, attempts to elucidate the impact of sleep extension on obesity in children have proved challenging. For example, an intervention that targeted multiple risk factors, including sleep behavior, was effective in reducing BMI in children, but because the intervention targeted multiple risk factors and because sleep was not measured objectively, the impact of changes in sleep duration per se on outcomes is not clear [59].

GAPS AND FUTURE RESEARCH DIRECTIONS

A Developmental perspective regarding the interplay between sleep and obesity

During adolescence, the pendulum of sleep and arousal regulation tends to encounter multiple forces pushing it away from sleep and toward high arousal [60]. As individuals progress through puberty, an evening preference becomes evident leading to delayed bedtimes and chronic sleep deprivation. The shift in bedtime has been attributed to psychosocial [60-62], and biological factors [63-65]. In parallel to the increased

prevalence of sleep deprivation in adolescence, the past 25 years have seen a considerable increase in the percentage of children and adolescents who are overweight or obese. The rise is particularly notable among those aged 12-17 years, wherein the overweight status/obesity rate more than doubled from 14-29%, and in whom obesity tripled from 3-9% [66]. Although both weight gain/obesity and chronic sleep deprivation peak in adolescence, as shown by many reports, an understanding of the interplay between these factors is currently lacking, and no current translational work aims to consider both issues in the development of a means to prevent childhood obesity.

Integrating sleep into programs aimed at obesity prevention and treatment

The benefits of integrating programs that emphasize specific interventions to improve health outcomes have been widely debated. In the context of interventions seeking to prevent childhood obesity, this is a critical issue, because multiple factors such as physical activity level, nutrition, timing and duration of exposure to screen time, and sleep duration are interrelated, and any emphasis on one element at the expense of other factors might compromise program benefits. Systematic analysis of the relative merits of integration in various contexts, and of different interventions, is needed. To date, no commonly accepted integration guidelines exist, no action plan has been developed to address this need, and no Knowledge Transfer/Translation strategies are available to address integrated health requirements needed for the prevention of childhood obesity.

SUMMARY

Adopting a new approach that considers the interplay between sleep, physical activity, nutrition and screen time, affected by the 24/7 lifestyle of a society that consumes too much food and is relatively sleepless is expected to revolutionize existing approaches to prevention and treatment of childhood obesity. Although convincing evidence shows that nutrition, physical activity, and screen time exposure interact with sleep processes, the mechanism by which this occurs as well as potential ways to use these mechanisms to treat obesity are unknown. Future studies examining the mechanisms underlying the interplay between these life-style factors and translating them to effective action are critically needed. This is expected to significantly advance the knowledge needed to prevent and treat child obesity.

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