

Relationship between the multidimensional 8-5-2-1-0 health guideline and adolescent obesity

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Abstract

In the context of growing concerns about maintaining and improving health, this study acknowledges the multifaceted aspects of health. This stands in contrast to conventional guidelines that often emphasize time and intensity of physical activity. This study aims to explore the significant advantages of embracing a more holistic approach to health recommendations, which take into account various contributing factors. The 8-5-2-1-0 guidelines, an extension of the Let's Go! 5-2-1-0 campaign, introduce a comprehensive model encompassing sleep duration, dietary habits, screen time, physical activity, and consumption of sugary beverages. This study explores the relationship between adolescents' adherence to the 8-5-2-1-0 goals and their body mass index (BMI), utilizing self-evaluation surveys from The Korea Youth Risk Behavior Survey (KYRBS), involving 57,303 students aged 13-18 years. Through the application of the Kruskal-Wallis test and subsequent pairwise post hoc comparisons, analysis reveals that roughly 1% of adolescents achieved four or more goals, where approximately 80% fulfilled only one or none. Notably, statistically significant differences in BMI were observed among groups meeting different numbers of goals ($p < .001$). Pairwise comparison results indicated significant differences between the groups, particularly the no-goals group and those achieving one [$p = .007$], two [$p = .000$], three [$p = .000$], and four goals or more [$p = .000$]. Additionally, significant disparities emerged among the groups with two, three, and four goals or more ($p < .001$ in all cases), highlighting the influence of diverse goal adherence on BMI outcomes. These findings hold significant importance as they recognize the obstacles schools encounter in promoting and incorporating each facet of the health guidelines due to cultural and social norms, school environments, and financial limitations. The findings suggest a pragmatic approach, encouraging students to prioritize at least two feasible health behavior components. This approach can reduce the pressure of meeting all criteria simultaneously, potentially boosting motivation and improving the chances of positive health outcomes. This underscores the advantages of comprehensive health guidelines compared to those centered solely on physical activity.

Keywords: Healthy behavior, physical activity, screen time, obesity, teenager

Introduction

The escalating worldwide obesity rates among children and adolescents present a pressing global health concern, having tripled in the last decade (Hales et al., 2017). Disturbingly, the Organization for Economic Co-operation and Development (OECD) has reported that overweight and obesity rates have surged, surpassing 50% in adults and nearly reaching 20% in children across OECD regions. The alarming escalation of obesity rates over the last decade presents a somber reality: every nation is grappling with this health emergency (OECD, 2020). Obesity not only increases the vulnerability to conditions like diabetes, hypertension, and cardiovascular diseases but also sets the stage for young individuals to more likely become obese adults (Goran et al., 2003; Rome, 2011). To counteract this concerning trajectory, interventions centered around schools have been developed to address and alleviate obesity risk factors (Barlow & Expert, 2007; Bucksch et al., 2016; Davis et al., 2007; Patrick et al., 2004; Polacsek et al., 2014).

Addressing the increasing imperative for health preservation and improvement, diverse health guidelines have emerged, including "Physical Activity Guidelines for Americans" from the US Department of Health and Human Services (Piercy & Troiano, 2018), and the "Dietary Guidelines for Americans" from the United States Department of Agriculture (2010). However, these guidelines often place undue emphasis on the duration and intensity of physical activity, neglecting the intricate interplay of diverse health influencers. Moreover, the World Health Organization's guidance suggests a daily intake of at least 60 minutes in moderate-to-vigorous aerobic physical activity throughout the week for adolescents (Bull et al., 2020).

This approach merely scratches the surface of the intricate health equation, disregarding the potential impacts of other pivotal health factors like nutrition, mental well-being, and sleep patterns. An urgent need exists for all-encompassing health guidelines that incorporate a wider range of health determinants, thus

promoting a holistic approach to health maintenance. In 2006, the US launched an influential initiative known as “Let’s Go! 5-2-1-0,” a nationwide designed to address physical activity, sedentary behavior, and dietary habits comprehensively (Foltz et al., 2011). Anchored in the social ecological model, this program acknowledges the intricate interplay between individual and environmental variables in determining health behaviors (Rogers & Motyka, 2009).

The implementation of the 5-2-1-0 guidelines within school settings led to a thorough assessment of its effects, emphasizing the significance of consistent health messaging (Rogers & Motyka, 2009). Within this framework, “5” signifies consuming a minimum of five servings of fruits and vegetables; “2” entails limiting screen time to two hours; “1” recommends at least one hour of physical activity; and “0” promotes avoiding sugar-sweetened beverages entirely.

Research founded on these guidelines uncovered a concerning reality, with only 0.4% of US adolescents meeting all four goals (Rogers & Motyka, 2009), and a mere 0.95% of US middle school students achieving the same (Cho et al., 2017). Recognizing the substantial impact of sleep duration on adolescent obesity (Narcisse et al., 2019), recent investigations have taken a novel approach by expanding the existing 5-2-1-0 guideline. In particular, a pioneering study, which incorporated a sleep duration recommendation into the 8-5-2-1-0 guideline, presented an enhanced predictive model for obesity in adolescents (Narcisse et al., 2019). Furthermore, notable research unveiled a substantial inverse correlation between sleep duration and BMI in adolescents (Lee et al., 2016). These results underscore the pivotal significance of sleep as a fundamental health behavior among this age group. Thus, the inclusion of the sleep element (specifically, endorsing a minimum of eight hours of nightly sleep) is suggested to offer a more comprehensive structure for analyzing health-related behaviors in adolescents. Amidst the validation of the 5-2-1-0 guideline through various studies, a noticeable gap in the current body of research lies in the investigation of the relationship between adherence to the augmented 8-5-2-1-0 recommendations and obesity. Consequently, the primary objective of this study was to delve into the potential link between adolescents’ compliance with the 8-5-2-1-0 goals and their corresponding BMI. Expanding upon the current research landscape, this study seeks to bridge an important gap in knowledge by exploring the potential correlation between adolescents’ adherence to the 8-5-2-1-0 goals and their corresponding BMI measurements. Should substantial connections be uncovered, this could pave the way for a transformative shift in health guidelines, elevating the role of sleep as a pivotal element in preventing obesity. This could ultimately reshape the trajectory of comprehensive health management for adolescents.

Methods

Subjects

In this study, an examination was conducted using the 2019 Youth Risk Behavior Survey, which was administered by the Korea Centers for Disease Control and Prevention (2020). The initial pool of self-evaluation surveys included responses from 57,303 students aged 13-18 years. After addressing missing data, the final analytical sample consisted of 50,445 participants. The data were analyzed and findings were presented with a 95% confidence level. The study received ethical approval from the Institutional Review Board of the Hanyang University (# HYUIRB-202102-010).

Measurement

This study incorporates five independent variables. Concerning sleep duration, the participants were asked: “At what time do you usually get up? At what time do you usually go to sleep?” Sleep duration was then calculated and categorized into two groups: “less than 8 hours” and “more than 8 hours.” As for fruit and vegetable consumption, the participants were asked: “During the past seven days, how often did you consume ... (1) Fruits? (2) Vegetables? — excluding fruit juice and kimchi.”

Regarding fruit and vegetable consumption, response categories were merged into “consumed ≥ 5 fruits and vegetables per day” and “consumed less than five fruits and vegetables per day.” For screen time behavior, survey participants were asked: “During the past month, how many hours did you spend on the Internet that was not related to schoolwork?” The screen time was quantified and categorized as $\leq 2 = 1$ and $> 2 = 0$. Physical activity levels were categorized as “physically active more than 60 min per day” and “less than 60 min per day.” The survey also assessed sugar-sweetened beverage consumption by asking, “During the past seven days, how many times did you drink a can, bottle, or glass of sugar-containing beverages such as soda, energy drink, or sweetened fruit beverage?” The responses were dichotomized into those without the consumption of sugar sweetened beverages and those with the consumption. BMI was calculated using height and weight data and using as the dependent variable of interest.

Statistical analysis

Data analysis was conducted using SPSS v. 25. Descriptive statistics were employed to categorize BMI into five groups, considering adherence to the 8-5-2-1-0 guidelines. The normality assumption was assessed using the Shapiro-Wilk test, and the result was statistically significant ($p < .05$), indicating a deviation from normality. Thus, the Kruskal-Wallis test, a nonparametric equivalent to a one-way ANOVA, was employed to determine differences in BMI among five adherence groups. A p-value below .05 was indicative of statistical significance. Post hoc comparisons were carried out using the Dunn procedure (1964) for pairwise analysis. Throughout the analyses, significance was established at a p-value of less than .05.

Results

Participant demographics

This study encompassed 50,455 adolescents enrolled in middle and high schools, with a gender distribution of 51.6% boys (26,014) and 48.4% girls (24,431). Overweight/obesity, defined by a BMI ≥ 25 according to the CDC (2020) criteria, was evident in 15.4% of participants. Although the disparity in BMI between girls (20.72 $\pm$ 3.05) and boys (21.92 $\pm$ 3.87) was modest, a notable distinction emerged in the prevalence of overweight/obese status, with boys (20.8%) exhibiting a considerably higher percentage compared to girls (9.6%). See Table 1.

Table 1. Descriptive analysis: Participant demographics

Gender	School	N (%)	BMI (mean $\pm$ SD)	BMI ≥ 25 (N, %)
Boys	Middle school	13,244 (50.9)	21.17 ± 3.77	2,194 (16.6)
	High school	26,014 (51.6)	21.92 ± 3.87	5,407 (20.8)
Girls	Middle school	12,770 (49.1)	20.12 ± 3.82	844 (6.8)
	High school	24,431 (48.4)	20.72 ± 3.05	2,341 (9.6)
Total		50,455 (100)	21.34 $\pm$ 3.55	7,748 (15.4)

Adherence to 8-5-2-1-0 goals

Approximately 1 in 4 adolescents (25.4%) achieved the eight hours or more of sleep recommendations; followed the guideline of consuming five servings or more of fruits and vegetables; approximately half (54.4%) adhered to the recommendation of limiting screen time to two hours or less; 6.4% fulfilled the guideline of engaging in one hour or more of physical activity; and only 4.5% refrained from consuming sugar sweetened beverages. Approximately 1% of adolescents achieved four or more recommendations in the 8-5-2-1-0 guideline; 2.7% of adolescents fulfilled three recommendations; 16.4% of adolescents met two recommendations; nearly half (47.7%) followed one recommendation; and around one-third (32.4%) did not adhere to any of the recommendations. See Table 2.

Table 2. Descriptive analysis: Adherence to the 8-5-2-1-0 guideline

Variable	N	%
8-5-2-1-0 Guideline	(8) Sleep duration (daily) ≥ 8 h	12,807
	(5) Fruit Vegetable consumption (daily) ≥ 5	1,543
	(2) Screen time (daily) ≤ 2 h	27,426
	(1) Physical activity (daily) ≥ 1 h	3,230
	(0) Sugar-sweetened beverage consumption (daily) = 0	2,248
Adherence to 8-5-2-1-0 guideline	Met all 8-5-2-1-0	70
	Met four guidelines	398
	Met three guidelines	1,353
	Met two guidelines	8,255
	Met one guideline	24,038
	Met zero guideline	16,311

BMI by adherence group

The results demonstrated a trend where participants with a higher number of met goals exhibited lower BMI values. The groups meeting four and five goals were combined into a single "four goals or more" group due to the extremely small number of adolescents meeting all five guidelines ($n = 70$, 0.1%). The group achieving four goals or more had an average BMI of 20.79; followed by the three-goals group with an average BMI of 20.90; the two-goals group with an average BMI of 20.95; the one-goal group with an average BMI of 21.38; and the group with no goals met having an average BMI of 21.53. See Table 3.

Table 3. BMI of groups formed by adherence of the 8-5-2-1-0 guideline

Adherence to 8-5-2-1-0 goals	N	BMI Mean	SD
Zero Goal	16,311	21.53	3.58
One Goal	24,038	21.38	3.53
Two Goals	8,255	20.95	3.56
Three Goals	1,353	20.90	3.29
Four Goals or more	468	20.79	3.39
Total	50,445	21.34	3.55

Association between guideline adherence and BMI

Significant differences were observed in BMI based on the adherence to the 8-5-2-1-0 guidelines (chi-square [4, $N = 50,455$] = 183.1, $p < .001$). Post hoc pairwise comparisons revealed significant differences between the group with no goals met out of the 8-5-2-1-0 recommendations and other groups with one goal [$p = .007$], two goals [$p = .000$], three goals [$p = .000$], and four goals or more [$p = .000$] and between the group with one goal and other groups with two goals [$p = .000$], three goals [$p = .000$], and four goals or more [$p = .005$]. However, the relationship between groups with at least two or more goals met out of the 8-5-2-1-0 recommendations did not show significant differences. Consequently, it was anticipated that individuals meeting a minimum of two of the 8-5-2-1-0 goals would expect to have lower BMI than their counterparts.

Discussion

This study aimed to establish a connection between adherence to individual 8-5-2-1-0 goals and adolescents' BMI. Despite the importance of healthy behaviors, the results showed that only 0.1% of adolescents in this study achieved all individual goals. This aligns with prior international research, illustrating that only 0.4% (Foltz et al., 2011) and 0.95% (Cho et al., 2017) of adolescents met all 8-5-2-1-0 goals and 0.6% (Narcisse et al., 2019) fulfilled all 8-5-2-1-0 goals. Interestingly, empirical evidence underscores a low rate of total compliance with these guidelines among adolescents. Previous research studies have consistently shown that only a small fraction of adolescents successfully fulfill all these health behavior goals (Cho et al., 2017; Haughton et al., 2016). Nonetheless, this adherence rate doesn't exhibit a uniform distribution across adolescents; instead, it fluctuates based on individual socio-economic determinants. For instance, financial limitations within lower-income households might impede the regular intake of five servings of fruits and vegetables. Likewise, densely populated urban settings could pose challenges for meeting the daily physical activity recommendation due to limited access to safe recreational spaces.

The outcome of this study, indicating that less than 1% of participants adhered to the 8-5-2-1-0 guideline, diverged from prior research outcomes. Nevertheless, the prevailing consensus is that meeting all the goals within the 8-5-2-1-0 guideline poses substantial challenges. Hence, there is a crucial necessity to formulate tailored, realistic, and attainable health messages specifically designed for adolescents within the school context (Rogers et al., 2013). The varying adherence levels observed among adolescents to the individual goals within the 8-5-2-1-0 guideline underscore the distinct patterns in health behaviors. Notably, our study revealed that nearly half of the adolescents met the suggested limit of two hours of daily screen time, while only a small 3.1% managed to meet the recommendation of consuming a minimum of five servings of fruits and vegetables. These findings align with previous research. The National Health and Nutrition Examination Survey (NHANES) conducted in the US highlighted a significant increase in daily computer usage for two or more hours, escalating from 30% in 2001–2003 to 43% in 2016 (Yang et al., 2019). Furthermore, there has been a worldwide shift in adolescents' screen time habits, where internet usage has swiftly overtaken traditional TV viewing (Bucksch et al., 2016). Our results are consistent with the findings of Park and Song (2019), who reported that 75.5% of adolescents spent two or more hours daily using a smartphone, including educational purposes. Moreover, our study underscores that merely a quarter (25.4%) of adolescents adhered to the recommended sleep duration of at least eight hours per day. Research has consistently shown that inadequate sleep can result in a range of detrimental health consequences, encompassing poor academic performance, mental health issues, and increased obesity risk (Adamakis, 2021; Beebe, 2011; Chaput & Dutil, 2016; Owens & Weiss, 2017).

The study underscores the importance of addressing the issue of inadequate sleep among adolescents, as it is a significant concern with only a quarter of adolescents meeting the recommended sleep duration. Educational institutions, parents, and healthcare professionals should prioritize initiatives aimed at promoting sufficient sleep duration among adolescents, forming a crucial component of a holistic strategy to enhance adolescent health and well-being. The disparity between the adherence rates to the sleep recommendation and the screen time recommendation might highlight the impact of technological distractions and academic pressures on adolescents. The prevalence of late-night device use or completing school-related tasks could potentially contribute to insufficient sleep among adolescents, underscoring the need for a comprehensive approach to address these factors and prioritize healthy sleep habits.

Indeed, the variations in adherence rates among these goals emphasize the necessity for tailored, contextually appropriate health messaging aimed at adolescents. Schools can play a pivotal role as strategic intervention platforms to impart personalized guidance and promote healthy behaviors, aligning with the overarching goal of enhancing adolescent well-being (Rogers et al., 2013). Furthermore, our study highlights the significant relationship between the number of 8-5-2-1-0 goals achieved and adolescents' BMI. The inverse relationship underscores the potential efficacy of targeted behavioral adjustments in fostering positive impact on adolescent health outcomes. This echoes earlier research that has identified a negative correlation between adhering to individual 8-5-2-1-0 guidelines and BMI percentiles in American adolescents (Cho et al., 2017; Narcisse et al., 2019). Taken together, these outcomes underscore the significance of instituting school-centered interventions and strategies, recognizing that adolescents predominantly spend their time in school, where their health behaviors are significantly influenced (Piko & Hamvai, 2010). Despite approximately 90% of teachers

showing interest in implementing the 5-2-1-0 or 8-5-2-1-0 guidelines in school settings (Rogers & Motyka, 2009), it appears impractical for students to attain all health objectives concurrently. This underscores the need for a strategy in which school personnel, based on their specific environment and interests, can emphasize a targeted set of goals from the 8-5-2-1-0 guidelines.

Remarkably, our research suggests that adolescents who fulfill at least two or more of the 8-5-2-1-0 goals exhibit similar BMIs. This insight could guide school staff in designing strategic interventions, allowing them to concentrate on two or three of these goals for more impactful obesity prevention, rather than dispersing efforts across all five targets in the 8-5-2-1-0 guideline simultaneously. To effectively implement health messages, such as the 8-5-2-1-0 guidelines, schools must offer a variety of programs, spanning before- and after-school activities, recess and lunch times, and intramural programs (Rogers et al., 2013). Incorporating strategies like motivational interviewing (Browne et al., 2022) could play a crucial role in instigating behavioral change among adolescents (Resnicow et al., 2002). Motivational interviewing is a student-centered counseling approach that empowers individuals to confront and resolve their ambivalence about behavior change. Through empathetic listening and positive reinforcement, this technique nurtures intrinsic motivation by emphasizing the mismatches between current behavior and future aspirations. However, conventional obstacles like time limitations, reduced engagement, and financial constraints frequently present formidable hurdles to the effective execution of school-based health interventions (Forman et al., 2009; Gittelsohn et al., 2003; Shaya et al., 2008). Therefore, school personnel should tailor their specific circumstances, including available facilities and budget, when devising 8-5-2-1-0 guideline strategies, and concentrate on a minimum of two goals from the 8-5-2-1-0 guideline to effectively mitigate the risk of obesity among adolescents. This study outlines essential health criteria for adolescents, yet it has certain limitations. The restricted scope of the sampled population underscores the necessity for future research encompassing diverse countries. Health determinants can significantly differ across cultures and nations, indicating that specific regions may prioritize distinct health factors beyond the scope of the 8-5-2-1-0 guidelines examined here. Thus, health guidelines tailored to the US context might not universally apply worldwide.

Conclusion

The study's findings emphasize the importance of devising personalized and context-specific health messages for adolescents, particularly within the educational setting. However, it's vital to acknowledge that frequently used guidelines, like the 8-5-2-1-0, can inadvertently prioritize only the duration and intensity of physical activity. This oversight disregards the intricate network of health determinants, demanding attention. The limited number of adolescents meeting all 8-5-2-1-0 goals underscores the intricate nature of achieving comprehensive health behaviors. A more pragmatic approach for educators and administrators might involve targeted emphasis on individual goals like sleep, nutrition, physical activity, screen time, or sugar-sweetened beverage consumption.

Opting for a select set of goals and leveraging techniques like motivational interviewing and/or tailored health programs, educational institutions can effectively aid adolescents in adopting behavioral changes. This approach could underscore the advantages of comprehensive health guidelines compared to those concentrating solely on physical activity. Continued research is vital to evaluate the effectiveness of school-based interventions, particularly those that targeting specific goals within the 8-5-2-1-0 guidelines. This assessment will unveil the most impactful strategies for enhancing health behaviors in adolescents. Considering the diversity of socio-economic contexts, future studies should explore tailoring guidelines to distinct settings for optimal outcomes. Acknowledging the diverse characteristics of different environments can enhance our ability to guide adolescents toward relevant health behavior goals.

As technology use becomes more prevalent among adolescents, upcoming research should investigate the feasibility of leveraging tools like mobile apps and online platforms to deliver personalized health messages and track progress toward these goals. This could offer a dynamic and effective approach to adolescent health management. Embracing technology within interventions holds promise for heightened engagement and effectiveness. Finally, for a holistic grasp of adolescent health behaviors on a global scale, forthcoming research should explore the multi-faceted influences that shape health across diverse countries and cultures. This approach could pave the way for universally relevant and culturally attuned guidelines, enabling cross-cultural insights and the exchange of effective strategies. Conducting longitudinal studies to gauge the enduring impact of adhering to the 8-5-2-1-0 goals on health outcomes, notably, BMI, is of paramount importance. These extended follow-ups can provide invaluable insights into the lasting effects of positive behaviors, thus shaping interventions that foster lifelong health and well-being. By addressing these proposed directions, we can enhance our understanding of adolescent health behaviors and cultivate evidence-based strategies to support their overall well-being.

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All authors declare that they have no conflicts of interest with any person, company, or institution.

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