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Review

School education and childhood obesity: A systemic review

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ABSTRACT

Childhood obesity prevalence is shooting up at a phenomenal rate worldwide, leading to long-term devastating consequences. A great number of studies have investigated factors contributing to the increase in BMI of children and adolescents. School-based, home-based and clinic-based solutions have been suggested as possible viable strategies, among which school-based interventions is believed to produce a noticeable effect on a massive scale. However, the question of whether school interventions, especially school education exert significant impact on childhood obesity or not, is left with mixing results. This article aims to holistically review the relationship between school education and childhood obesity. Various factors are covered, including health education, nutrition education, school nutrition, physical education, teachers' awareness, teaching practice and school stress, In all, school education is not the answer to childhood obesity but just part of it. More attempts from other stakeholders (parents, community, policy makers, researchers, etc.) should be made in order to solve this complicated puzzle.

1. Introduction

For every three people we encounter down the street, one would be considered overweight or obese [1]. Despite strenuous efforts and research in the field, obesity remains a critical health problem worldwide and its prevalence does not seem to cease. For the last three decades, no country has shown a significant decrease in obesity [1]. Overweight and obesity have soon become a trend in wealthy communities. Noticeably, it has now spread out from better-off nations to other mid and low-income countries [2]. Obesity can truly be a threat to anyone, any family, regardless of their age, gender, race and family background. Obesity closely links to various mortal diseases and chronic health problems such as diabetes, cardiovascular diseases, cancer and mental health [3,4]. In 2015, high Body Mass Index (BMI) accounted for 4 million deaths of all causes worldwide, in which cardiovascular ranks as the top killer [5]. Those numbers speaks for themselves. The trend is actually a burning issue requiring more comprehensive strategies and action plans against the epidemic.

The number of overweight adults is disconcerting and even

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higher than that of obese children. Childhood obesity prevalence is more alarming, occurring at an unprecedented rate [6]. In 2016, the total number of obese children all over the world were estimated to be 124 million. Within 4 decades (1975–2016), the global prevalence of obesity has increased up to 4.9% among girls, and 6.9% among boys [2]. High BMI in early ages tightly links to several negative health consequences in adulthood [7,8] It associates with higher odds of such chronic diseases as type 2 diabetes and cardiovascular diseases. In addition, this vulnerable young-age group is also the target customers of corporations of processed food and energy-dense products [2].All these above insights suggest why a comprehensive multi-level solution to childhood obesity need to be put forward for the sake of a healthier lifestyle for future generations.

Body Mass Index (BMI, in kg/m2) is a commonplace metric indicator measuring body fat based on the weight and height of an individual. Obesity is a consequence of excess body weight and often explained with positive energy balance. The concept about energy balance is presented as below:

Energy balance = energy intake - energy expenditure.

The obesity epidemic is often approached in two ways: either to decrease the energy intake through promoting a healthy eating diet or either to maximize the energy burned. For decades, thousands of schools around the world have been making relentless efforts to increase physical activity time at school. Though many school-based physical-activity interventions have been made, numerous studies have raised a concern of how much these efforts really pay off. It was argued that school physical activity did not show much success in improving BMI in students [9–13]. J. Flatt et al. pinpointed a commonplace misconception about obesity in relation with the energy balance concept [14,15]. It was explained that the two elements rather than considered to contributing equally to the energy balance, in fact, have a direct association. In other words, the energy intake of an individual self-regulates to adapt accordingly to the energy loss. Also, it was brought to discussion that the cause of obesity derived from the malfunctioning in sending the message about food intake regulation to the body in order to restrain from overeating. Another concern was that physical activities outside school context my decrease even if school-based intervention can be very effective [16].While further research is continuing to be conducted and case-studies to be analyzed about the contribution of energy intake and energy expenditure to the balance energy point, it is helpful to note that childhood obesity cannot be tackled effectively with one-sided approaches.

In fact, holistic approaches to obesity interventions have been suggested for over a decade [17–19].Overweight in children and adolescents has been tackled in various fields: from family to school, from individual to community and from local stakeholders to policies of all kinds. With strenuous efforts, several developed countries have started to witness an appreciable sign of stabilization in obesity rate [20,21]. However, there is still a long way to go since the current BMI index remains high. Additionally, an enormous number of studies focus on school-based interventions as a critical method against obesity. Nonetheless, reports showed that obesity prevention school programs have disappointing results [22].Obviously, the gap between awareness and implementation should be bridged, in which school education-key factor in the campaign against obesity-must be placed in the central focus. This article reviews current trends in childhood obesity across countries, discusses impacts of school education on childhood obesity and suggests how an interdisciplinary approach at school can make a difference to a child's life in the battle against excess weight and obesity.

2. The epidemic of childhood obesity

Childhood obesity is commonly defined as BMI ≥95th percentile [23].Regarding the global childhood obesity epidemic, one-in-five children is affected with this health problem [24]. In 2016, 41 million below-5-year-old students suffered from pre-obesity [25]. Data collected in the same year revealed that roughly 50 million girls plus 74 million boys were living with obesity [2]. In most countries, boys gain weight more easily than girls; those in urban areas are more likely to be exposed to the trend than those in the countryside; children in developed countries are more obesity-prone than their peers in developing nations. Since 2000, there has been a plateau in the BMI index in numerous high-income countries. Regrettably, the obesity rate has started to accelerate dramatically in Eastern, Southern, South-Eastern Asia [2,24] and Oceania [25].

Contributing factors to the rocketing childhood obesity rate in the last 4 decades include a transition in nutrition intake, socio-economic development, behavioral and environmental changes as well as technological advancement. Nowadays, children have a less healthy food choice due to the strong promotion of mass processed products and their huge availability with a wide variety in the market [6,26].Their food choice is considerably influenced by TV and Youtube channels dominated by advertisements for obesogenic food [27–29] In addition, the emergence of all kinds of media and social networks, online games and services disconnect the children with the real world and other interactive activities [6,30]. These examples partly explain how children have become the victim of an obesogenic environment. In the latest article about financial burden of obesity, Hamilton et al. suggested an estimated total lifetime cost for an average obese child of €150,000, including both direct (health care) and indirect costs (productivity loss) [31].Obesity causes the subjects not only thorny financial concerns but also long-standing physical and mental problems. Childhood obesity has a direct link to high possibility of adulthood obesity, which again emphasizes an urgent need for obesity intervention in the early ages [32].

The overall picture of childhood obesity worldwide is gloomy. The situation has especially become a mounting concern in developing countries, notably in Asia [2,24,33]. However, little extensive data is available in these countries [34]. In 2010, there was an estimated number of 35 million children from developing countries worldwide affected with either overweight or obesity [35].WHO Africa had the lowest obesity rate of around 10%. [33] A research conducted across 7 countries in Africa from 2006 to 2010 reported an obesity rate varying between 0.6% (Benin) and 9.3% (Egypt) [36].Overweight prevalence in Egypt was exceptionally stunning at a percentage of 31.4%. China lead the obesity trend with a rocketing rate from 0.2% up to 8.1% within 2 decades [37]. In 2010, the prevalence of overweight across China among 7-18 year-old school-goers was 19.2% [38].India shared the same ranking with China with a percentage of 19.3% (data 2010) [39]. In Vietnam, data collected in 2016 showed an overweight rate among pre-school children in urban and rural areas of 25.6% and 7.7% respectively, whereas the prevalence of obesity in the two areas were 7.1% and 1.9% [40].In Ho Chi Minh city-one of the most dynamic city in Viet Nam, the prevalence rate of pre-obesity and obesity increased by 15.1% (5.9–22) within 6 years [41].Aspectssetting the trend in developing countries include: unhealthy food intake, sedentary lifestyles, traditional beliefs, exposure to westernized dietary habits, etc. [33].

Even though these data do not seem to be much startling as compared to those of countries with high-living standards, the

situation is actually much worrying, considering three factors. Firstly, data in various low and middle-income countries is an indicator for a continuing increase in childhood obesity in the coming decades. Secondly, most developing is bearing a so-called “double burden of malnutrition” in which over-nutrition and over-nutrition co-exist [6,42]. Finally, infrastructure and socio-economic structures of these countries are either unstable or during a transition; Hence, in the era of digital and industrialization as well as the exposure of western culture and lifestyles, these countries need to find for themselves a strong identity and set out a long-term national strategy against the epidemic.

3. The impacts of school education on childhood obesity

3.1. School health education and childhood obesity

Health education as LW Green, MW Kreuter put: “any combination of learning experiences designed to facilitate voluntary actions conducive to health” [43].Health education is the most direct pathway to help improve childhood health literacy-the ability and skill sets to understand and interpret health information to make sensible decisions related to their personal health [44]. According to CDC (Centre for Disease Control and Prevention), a health education curriculum must provide functional health information, construct values and beliefs promoting healthy lifestyles, equip skill sets to develop and practice healthy behaviors [45]. Its topics variously range from nutrition to injuries, from alcohol to HIV prevention, physical activities, etc. [45].

Since 2015, there has been scientific evidence proving the impact of health education enhancement on childhood obesity as in Taiwan [46], China [47] and the America [48]. According to CDC 2017 report, 53,75% schools nationwide required students to take at least 2 health education courses. These relentless efforts of schools here and there, attempting to reserve the current status of childhood obesity are worth recognizing. It is apparent that when students are fully-aware about health, they will have better choices regarding lifestyles and dietary habits, increasing their chance to improve BMI. However, for students in developing countries, the idea is more like an elusive vision. Even if students in those countries were impeccably educated about health, they would have little opportunity to improve their body weight status due to the poor infrastructure and health care service, food security crisis, lack of well-trained teachers and health care workforce, etc.

Roopa Chari et al. proved a tight association between health literacy and BMI of adolescents (aged 12–19). For children (aged 7–11.9), the odds of getting childhood obesity mostly depend on parents’ health literacy [49]. However, in both better-off countries as well as in less-wealthy countries, the number of health-literate parents is disappointing low [50]. Therefore, school health education should involve not only young school-goers but also parents and caretakers in order to minimize cases of childhood obesity. In addition, little is known about health literacy in children, adolescents and young adults [51]. Health education guidelines are also restricted, especially for countries in a weak socio-economic context-where childhood obesity rate is rocketing. Lastly, there needs to be a comprehensive validated standardized test for children [52] and adolescents [53] for a more effective measurement system.

3.2. Nutrition education and childhood obesity

Nutrition education is crucial in the campaign against obesity since it decides what and how students form their dietary habits, which could exert far-reaching effects on childhood obesity prevalence. As defined in Contento's book: “Nutrition Education is any combination of educational strategies, accompanied by environmental supports, designed to facilitate voluntary adoption of food choices and other food- and nutrition-related behaviors conducive to health and well-being. Nutrition education is delivered through multiple venues and involves activities at the individual, community, and policy levels.” [54].

According to FAO Nutrition Division's review in 50 countries, nutrition education is currently integrated into other subjects rather than implemented as a separated course [55].Only a few countries developed a comprehensive nutrition education curriculum [55].The present health promotion programs mostly focus on creating a healthy eating environment for kids instead of offering them the tools to have the right food choices and strategies to build up a healthy diet. Up to the present, there does not exist any national nutrition education standards or benchmarks [56].The need of a curriculum was said to be extremely urgent, regarding the fact that one third of the young population is either overweight or obese. Nutrition education experts suggested a 40–50 education hours in order to see the effect. (Whereas one school year requires 1000 h of class instructions). It was also discussed that the guidelines for nutrition education should aim to improve students' food literacy, equip them with food preparation skills and enhance physical activities.

A decent nutrition education is supposed to help students set an appropriate belief about healthy dietary habits and to create an environment where stakeholders collaboratively work together to support actions [54]. It is emphasized that the ultimate goal of nutrition education is to help students build up healthy dietary behaviors [56]. Education nutrition is considered a failure if students show an improvement in nutrition knowledge's score without any positive change in their dietary habits. Therefore, BMI is expected to show improvement only with persisting nutrition program including behavior modification [57]. A systematic review conducted in 2011 showed the effects of nutrition education on reducing overweight and obesity [58]. There was evidence worldwide proving positive effects of nutrition education on children's food preferences [59], self-efficacy [60], nutrition knowledge [60], increased physical activities [61], improved BMI z-score [61] and waist circumference [61]. Activity-based methodology (such as plays, games, stories, song, related to nutrition, nutritional diaries, discussion, cooking) was able to generate a strong motivating among young students [62].In ahands-on nutrition education program, control groups exhibited a frequency in checking food labels before their purchase and choosing processed food with less additives [63].Beside tradition nutrition education courses offered at schools, several creative initiatives have been launched to build up healthy eating behaviors in children such as: online nutrition education program [64], school garden [65], farm tour [66], nutrition education accompanying with food culture, even board game [67] and so on. However inventive and variable current nutrition education forms might be, nutrition education must be promoted further considering the possible link between food literacy and dietary intake [68,69], and the limited number of effective adolescent food literacy programs supporting dietary behavior changes [70].

3.3. School food environment and obesity

Patricia M. Anderson and Kristin F. Butcher pointed out that every 10% point increase in junk food accessibility at school resulted in 1% childhood BMI gain [71].A deficiency of specific types of food like fruit and vegetable will also lead to higher odd of childhood overweight and obesity [72].Nevertheless, students worldwide are exposed to an obesogenic school environment with high-energy-dense products, fast-food, unhealthy beverages available in

canteens, outlets and even in school meals. Only after 15 years since the establishments were National School Lunch Program (NSLP) and the School Breakfast Program (SBP) updated on their nutrition standards-more fruit, vegetables, whole grains and less fat and sodium per serving.

The introduction of school lunch and meal subsidy brought about more promising dietary benefits as compared to when students packed lunches themselves [73,74].Studies suggested that a low-energy-dense diet will attenuate BMI and obesity risk among school-goers. Although findings about the direct interaction between diet pattern approach and childhood BMI is null, healthy diets were asserted to associate with various healthy behaviors. As a result, plant-based meals [75,76] were recommended as another answer to childhood obesity prevalence. At the same time, interventions on students' accessibility to soft-drink [77], vending machine [77] and competitive food [78] were highly suggested to control their calorie intake. In the latest review on school food environment and obesity, C. E. Driessen et al. emphasized the positive impact of dietary environment intervention on either childhood BMI or eating behaviors [79].

For all that, in a review published in 2009, school-based food showed little evidence to have considerable important impacts on obesity prevalence [80].This research also mentioned the failure of school food policies due to the increase of other processed-food consumption in compensation for the inaccessible to the "banned" products. Again, it indicates that school nutrition intervention alone is a one-sided approach to childhood obesity. Besideefforts to maintain the energy balance, children and young adults should learn how to regulate themselves in such an obesogenic eating environment [81].

3.4. Physical activity in school and childhood obesity

Children and young people worldwide are recommended to have at least 60-min physical activities (of moderate or vigorous type) per day in order to improve fitness and reduce the risk of metabolism-related health problems [82]. Moreover, the majority of students spend most of their energetic time at school with their peers and teachers, participating in classroom and other extracurricular activities. Hence, school sounds a very sensible setting for physical activity interventions in childhood obesity. However, due to financial constraints as well as a mounting academic pressure that schools and administrators are withstanding, physical activity/training at school is not receiving deserving attention.

School-based physical activity interventions include obligation of a PE period [83,84], physical break time [83], physical activity homework [83], before and after-school activities [85,86], integrating moving and physical activities into an academic session [86], etc. Among various types of physical activity interventions for adolescents, sports participation proved to be among the most effective [87]. Physical education does not develop significant relationship with IBM improvement among adolescents, mostly because physical education periods at school do not involve sufficient intensity and duration to burn out the excessive calorie intake [88]. Physical education classes, however, completely works in reducing BMI of small children [88].Another amazing discovery is that physical activities could loosen the association between stress and BMI [89] or adiposity [90]in youth. H. V. Lavelle et al. in their systematic review published in 2012 found that physical activities either in isolation or when combined with nutrition-related interventions, associated with BMI decline in children and adolescents [91]. In all, increasing physical activity/training in school is a very effective strategy to be aimed at among the current school-based obesity interventions.

3.5. School stress and childhood obesity

We are actually living in the world of pressure where seemingly everyone is infected with mental health problems. Most adult workers perceive stress from their workplaces [92]whilst younger generations experience stress from academic institutions. In 2016, 12.8% students of the US aged 12–17 population were reported to be undergoing a depressive episode [93]. In developing countries where academic achievement is seen as an indicator for career success, stress prevalence and its consequences are even thornier [94,95].Also, it was discovered that stress was weighing more on girls [96].School-related stressors among adolescents are numerous: academic performance [97,98], examinations or high-staked exams [99], heavy workload, packed school time-table [98], competitive learning environment [97], future uncertainty [97], lack of playing time [97], stress associated with immigration and discrimination [100], etc. As to younger school-attenders in primary schools, 70% often have stress with pervasive hassles like "my friends making fun of me", "teacher did not listen to me" [96]. This demonstrates a loss of control over the daily encounters that any child at this age would expect to confront.

Stress and obesity are seen as bi-products of the fast-paced modern world. These two health problems have been suggested to form an intimate association. Chronic stress positively affects the aetiology of obesity by encouraging an individual's energy intake. During stress episode, cortisol is excreted to improve appetite, especially sugar and fat [101].Because of the instant effect of obesogenic food in alleviating stress, most people choose it as a temporary escape from mental pressure, regardless of later consequences of overweight and obesity they might face. In 2012, Groesz LM et al.linked stress exposure with the drive to eat in women [102]. Results revealed that stress (perceived and chronic) reduced an individual's ability to win the drive of overeating and palatable unhealthy food consumption [102]. As much as 43% US girls and 15% boys fell into stress-driven eating habit (2014 statistics) [103].Interestingly, a counter hypothesis has been raised up: weight gain even induces more stress and appetite, completing the circle among emotional tension, drive to eat and high BMI [102]. Therefore, in the attempt to break the stress-obesity circle and improve BMI, identifying and dealing with stressors is a very necessary step.

Several recent studies proved a direct link between the exposure to chronic stress and the increase in BMI among adolescents [104]. Obese or overweight adolescent girls are more likely to gain weight if they withstand psychological pressure. Another study pointed out the pressure of homework as an obesogenic factor in children [105]. Boys with a huge workload experience more mental anxiety [105].As a result, these subjects exhibited a more unfavorable adiposity indicator. Although the direct link between school stress and obesity is not very obvious, there is striking evidence of a direct association between school-related tension and less healthy dietary behaviors, which actively contributes to later obesity development. In all, school stress is a highly potential factor resulting in overweight and obesity in children and adolescents. Rigorous actions to manage school stress (involving learning environment, academic load, assessment system as well as courses on dealing with stress) must be performed in order to curb childhood obesity prevalence.

3.6. Teachers' awareness and perception towards obesity

To implement any health school education programme successfully, teachers'awareness is always considered as the first noticeable factor. For exploring factors affecting to childhood obesity. Teachers' awareness can not be ignored. A study in German kingarten schools showed that kindergarten teachers cannot

recognize whether obese students or not, there was just 44.6% of teachers in the study's data being able to identify overweight children correctly [36,106]. Moreover, in the finding of one study the knowledge level of teachers about nutrition remained low although they received the training of health programme; teachers along with schools play an important role in health promotion such as nutrition programme [107]. The relationship between teachers' perception and obestity has been also figured of burdensome of obese students. Because of personal and/or societal biases of teacher, children with obesity has been faced with more burdensome and more specific challenges comparing their peers [108]. One of the first study in England to understand teacher views and capacity of conducting an obesity prevention programme in school found out that to guarantee the success the prevention interventions should be in type of hands-on, manageable, suitable time formats for teachers and be flexible to the each schools' needs [109] Systemmatical approach to raising health-related awareness, attitude and behaviors of school teachers would make positive results in improving the behaviors of school-aged children [110].

3.7. Teaching practice and obesity

While most of the current obesity intervention programs are school-based, classroom movement integration is another possible factor contributing to childhood obesity improvement. This approach is seen as one among the most cost-effective obesity interventions since it only requires a slight change in teachers' teaching practice. In this way, teacher will design classroom activities that involve students' movement in academic periods.

Movement in the classroom does not only create more movability for students but also help optimize brain function [111].Suggested classroom-based activities include crunches, ball toss and catch, one-legged hops. Push-up holds or wall-sits, etc. [111] A case study conducted in 2011 proved the effect of physical activity breaks in preschoolers' movement in the classroom [112]. Results showed that physical activity break considerably contributes as much as a quarter of the required 60 daily minutes [112]. This type of break allows students to move actively in the classroom and get them ready for the next activity. Currently, there is only a limited number of studies concluding a possible positive relationship between classroom movement and BMI/BMI z score [113,114].Hence, further study on this pathway should be carried out.

As for teachers, they are fully aware of the significant impact of movement on obesity prevalence and the majority exhibit their willingness to integrate movement into their classroom [115].Though, building a class of movements is seen as a behavior change for a great number of teachers [115]. Well-conscious about this challenge, in 2013, Marietta Orlowski et al. introduced My Classroom Physical Activity Pyramid as a guideline to boost physical activity in a classroom setting [116].Nonetheless, more instructions and support are still needed to assist teachers on this arduous task.

4. Conclusion

Current studies suggest an existence of a close relationship between school education and childhood obesity. Firstly, education at school contributes to raising students' awareness of health and nutrition, hence enables them to make more well-informed food choices and to adopt healthier lifestyles. Secondly, interventions such as controlling energy intake (through school nutrition programmes) or efforts to maximize the energy expenditure (by creating more opportunities for students to move, either inside or outside classroom), also make contribution to their energy balance maintenance. Additionally, psychological factors like school stress and pressure also exert positive effects on IBM in children and adolescents. Although the effect of each approach on BMI/BMIz score remains ambiguous, the majority of school obesity intervention strategies in combination seem to produce impressive results as compared to when they are implemented in isolation. By the same token, regarding the alarming rate of recent obesity prevalence rising in developing nations and the limited guidelines on childhood obesity prevention in these countries, more research is warranted in order to prepare 90% children worldwide for the widespread epidemic. School-based campaigns alone cannot reverse childhood obesity prevalence unless there is a supporting ecosystem where schools, families, communities and policy makers all joining hands to create a local healthy environment assisting our descendants to apply a healthier lifestyle.

Conflicts of interest

No conflict of interest was reported by the authors.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dsx.2019.07.014.

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