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# Importance of movement behaviors in overweight and obesity development in children and adolescents: a narrative review.

# Importancia de los comportamientos de movimiento en el desarrollo de sobrepeso y obesidad en niños y adolescentes: una revisión narrativa

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**Abstract:**

Obesity (OB) is a multicausal disease, in which different components of the environment interact with the individual and can be transmitted intergenerationally, occurring at increasingly younger ages. Physical activity (PA), sedentary behaviors (SB), and sleep (S), referred to as movement behaviors (MB), are considered some of the main factors affecting overweight (OW) and (OB). International guidelines have published recommendations for these behaviors. In Mexico, more than half of the children and adolescents do not comply with the policies, which could be contributing to the present epidemic of OW and OB. Therefore, knowing how physical inactivity, SB and short sleep duration are related to energy expenditure and intake is relevant. This narrative review aims to describe the importance of MB in developing OW and OB in children and adolescents.

***Keywords:***

*Movement behaviors, overweight, obesity, schoolchildren, adolescents.*

**Resumen:**

La obesidad (OB) es una enfermedad multicausal, en la que interactúan distintos componentes del ambiente con el individuo y puede transmitirse inter generacionalmente, presentándose a edades cada vez más tempranas. La actividad física (AF), las conductas sedentarias (CS) y el sueño (S), denominados comportamientos del movimiento (CM) se consideran como unos de los principales factores que inciden en el sobrepeso (SP) y la OB. Directrices internacionales han publicado recomendaciones para estos comportamientos, en México más de la mitad de los niños y adolescentes no cumplen con las pautas, lo que podría estar contribuyendo a la presente epidemia de SP y OB. Por lo que es importante conocer como la inactividad física, las conductas sedentarias y la corta duración del sueño se relacionan con el gasto y la ingesta energética. El objetivo de esta revisión narrativa es describir la importancia de los CM en el desarrollo de SP y la OB en niños y adolescentes.

***Palabras Clave**:*

*Comportamientos del movimiento, sobrepeso, obesidad, escolares, adolescentes.*

## INTRODUCTION

Overweight (OW) is defined as an excess of body fat, while obesity (OB) is considered a pathological condition characterized by organ and tissue dysfunction due to excess adiposity.[1] The prevalence of childhood OB is increasing worldwide; estimates made by the World Obesity Federation for the year 2030 estimate an increase of 146.3 million.[2] Mexico occupies one of the first places in childhood OB in the world, preceded by China, the United States, India, and Brazil. In 2019,

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it was estimated that more than 5.1 million children and adolescents (5 to 19 years) had an OB diagnosis.[3] Currently in Mexico, 3 out of 10 schoolchildren present OW or OB.[4]

The etiology of OB is complex, as it involves multiple causes of various types. For childhood OB, the following risk factors have been identified: nutrition and diet, socioeconomic factors, comorbidities and health system-related factors, mother-related factors, physical activity (PA) and duration and quality of sleep.[5] The onset of OB can develop from gestation, and it is considered a multigenerational disease that goes from prenatal, neonatal, childhood, adolescence, and adulthood, so it is urgent to establish strategies from very early ages that can reduce the OB number and avoid long-term complications.[6] For more than twenty years, childhood OB has been recognized as a predictor of adult OB.[7]

Among the most recognized explanations for OB is the positive energy balance, which is an imbalance that arises when energy intake through food is higher than energy expenditure, leading to energy storage in the form of fat. The primary factors that influence overweight (OW) and obesity (OB) development are the interactions between diet and physical activity (PA). Research shows that both the quality and quantity of food as well as the time spent in PA, have an impact on the development of OW and OB.[5]

In this sense, recommendations have been published for compliance with the so-called movement behaviors (MB), which include the study of PA, sedentary behaviors (SB), and sleep duration (S); the combination of these behaviors are relevant indicators for children's and adolescents' health, and specifically, they have shown to contribute to the current epidemic of childhood OB.[8,9] Research carried out in 12 countries showed that schoolchildren who complied with the recommendations for each behavior were less likely to present OB.[10]

On the other hand, the international study of childhood OB ISCOLE demonstrated that children who met all three recommendations were 72% (OR 0.28, 95CI 0.18-0.45) less likely to develop OB than those who did not meet the recommendations.[11]

In this sense, this narrative review aims to describe the importance of MB in OW and OB development in children and adolescents.

## MOVEMENT BEHAVIORS

The MB is based on the PA performed by a person in a 24-hour (h) continuum ranging from no movement to high intensity. The study includes PA, SB, and S duration; these behaviors are studied from the time use approach epidemiology, which focuses on individual and social allocation in a given period, as well as the factors involved in the choice of time use.[12] A general description of each behavior follows.

PA refers to any bodily action produced by skeletal muscle contraction that increases energy expenditure above basal.[13] To determine the PA level, type, duration, and intensity should be considered. Concerning intensity, the latter is classified by considering the consumption of metabolic equivalents (METS) about the expenditure consumed at rest, in the following categories: light physical activity (AFL=1. 5-3 METS), moderate physical activity (MPA = 3-6 METS), vigorous physical activity (VPA= 6-9 METS) and moderate to vigorous physical activity (MVPA= 3-9 METS), on the other hand, physical inactivity is characterized by insufficient activities of moderate or vigorous intensity, or when specific PA recommendations are not met.[14]

One of the concepts that forms part of PA that needs to be differentiated is exercise, which is a planned activity that aims to improve physical fitness; for its part, physical fitness includes cardiovascular endurance, muscular strength, flexibility, coordination, and body composition, factors associated with health. These elements are essential for the development of motor skills in childhood.[15-19]

SB is defined by waking behaviors characterized by energy expenditure of 1.5 METS or less while sitting or lying down. Therefore, evidence has shown that regardless of whether high levels of PA are achieved, the time spent in sedentary behaviors has implications for the physiological response and how it is measured.[20] These behaviors have been associated with an increased likelihood of premature death and the presence of cardiovascular disease.[20]

Finally, S is a neurobehavioral state of disconnection from the perspective of the environment, where necessary processes of repair of the organism arise, being an indispensable factor during childhood and adolescence where there are relevant cognitive and neurological development processes[21], alterations in S habits can manifest as nocturnal awakenings, bedtime resistance, sleep anxiety, sleep disordered breathing, parasomnias and daytime sleepiness.[22]

For MB, the most relevant areas of interest are the relationship between time use patterns and health, and the effect of time use interventions.[12] Evidence has generally linked these factors to unfavorable outcomes for physical, mental, and social health among children and adolescents, with potential persistence into adulthood.[23-26] At present, there are 24 h movement guidelines, mainly for children and adolescents (5 to 17 years), the recommendations suggest performing $\geq$60 min/day of MVPA, limiting SB $\leq$2h/day and sleeping between 9 to 11 h (5 to 13 years) and 8 to 10 h (14 to 17 years) (see Figure 1).[9,27]

## EPIDEMIOLOGICAL OVERVIEW OF MOVEMENT BEHAVIORS

Physical inactivity is the fourth leading risk factor for mortality from chronic non-communicable diseases (NCDs), resulting in an estimated 3.3 million deaths each year worldwide. Between 6 and 10% of these deaths are attributed to NCDs. In low- and middle-income countries, physical inactivity accounts for 70% of deaths. [28-30] Recent data indicate that globally, 27.5% of adults and 81% of adolescents fail to meet the recommendation

of engaging in at least one hour of daily vigorous physical activity. [14]

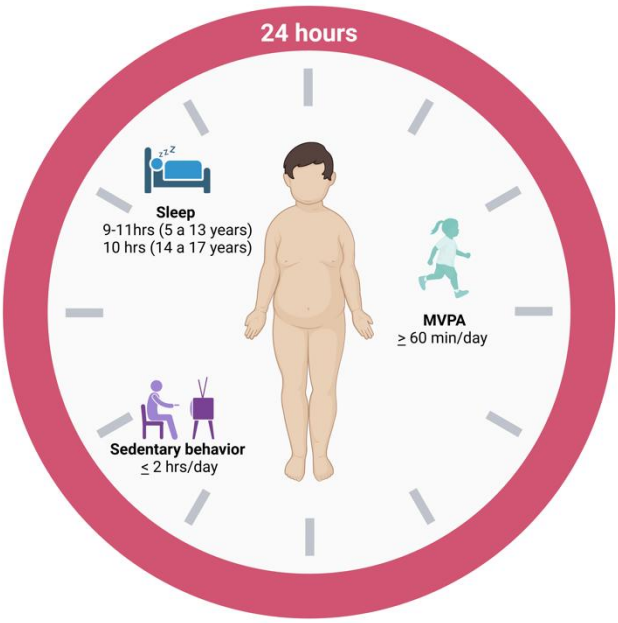


**Figure 1. Recommendations on movement behaviors for schoolchildren and adolescents.[9,27]**

SB studies have found that, on average, children spend 8 hours a day sitting, that is, half the day in a state of wakefulness, and during the school day, more than 60% of the time they remain sedentary.[31] These studies also report that children accumulate higher sedentary periods during the school day than those out of school or during the weekend.[32]

On the other hand, the time spent sleeping has decreased over the years. A systematic review found that children and adolescents (5 and 18 years) have decreased, on average, more than 1 hour of sleep per night, as well as differences by age, sex, type of day (weekday or weekend), and region.[33] Recent data identified that the prevalence of short sleep in children aged 7 to 12 years may be 64.5% more frequent on weekdays and 19.5% on weekends.[34] Research conducted in different racial and ethnic groups found a prevalence of short S duration of 34.7% in children aged 6 to 12 years.[35]

The global evidence on these behaviors is scarce, and prevalences vary by country and region. A systematic review of studies from 23 countries, conducted in children and adolescents found a prevalence of 7.12% in compliance with PA, SB, and S recommendations. 19.21% did not comply with any of the recommendations for each behavior.[36]

In Mexican schoolchildren, the available information on MB is not favorable: 7 out of 10 children perform less than 60 minutes of MVPA, 8 out of 10 schoolchildren spend more than 2 hours a day in front of a screen and 6 out of 10 schoolchildren sleep less than recommended (9 to 11 hours/night).[37]

It is important to mention that these behaviors were affected by changes in the social dynamics during the COVID-19 confinement period, resulting in a decrease in PA, an increase in SB, and an alteration in the hours of S.[38]

## MOVEMENT BEHAVIORS AND THEIR RELATIONSHIP TO OVERWEIGHT AND OBESITY

### PHYSICAL ACTIVITY

Over the years, studies have shown how PA positively influences children's health. Among the multiple results are the development of strength, flexibility, cardiorespiratory fitness, improvement of cardiometabolic indicators, cognitive development, and mental health.[16, 39-41] A study observed that children who engaged in MVPA had a 51% (OR 0.49; 95 % CI 0.44-0.55) lower probability of developing OB.[42]

Conversely, an association has been observed between PA and elevated body mass index (BMI), body fat and metabolic diseases associated with OB.[39, 43-47]

As explained above, one of the most studied causes for developing OB is the imbalance between energy intake and expenditure, and this relationship forms the basis of appetite control.[48]

Studies with short-term, medium-term, and long-term interventions focused on increasing PA have pointed to an increase proportional to energy intake, explaining that it is a way to compensate for the energy expended.[49-51]

On the other hand, exercise increases the sensitivity of the appetite control system, decreasing excessive food intake.[52]

Several investigations have described the phenomenon called exercise-induced appetite suppression, where the sensation of hunger temporarily decreases during exercise performed at 60% or more of maximal oxygen uptake (VO2).[53-57] Similarly, a decrease in ghrelin, the hormone that stimulates appetite, has been observed.[56-57] A systematic review in children and adolescents showed that acute exercise did not affect energy intake in lean youths. However, there was a reduction in food intake in young people with OB.[58]

Recently, a meta-analysis studied the effect of acute PA on food intake in children and adolescents, which showed that acute exercise did not compensate for an increase in food intake, regardless of characteristics such as age, body weight, or exercise intensity, leading to a negative energy balance[59] and weight loss.

### SEDENTARY BEHAVIORS

For more than a decade, the physiology of sedentary behaviors has been studied independently of exercise; the globalization of societies has affected daily life, school, domestic and work tasks demand less energy and more SB; in the case of children and adolescents, screen behaviors, such as watching television and playing video games, can be observed.[60]

In this sense, research has shown that watching television involves low energy expenditure and high food consumption, independently of the appetite sensation. [61-63] One of the principal causes widely studied is habituation to food signals, a phenomenon controlled by integrated signals from the sensory,

neuronal, and digestive systems.[64] Habituation can be affected by food and non-food cues, which are interrupted by watching television ; research has shown it causes distraction in children, delaying satiety cues, and resulting in higher caloric intake.[64-68] A meta-analysis concluded that a one-hour increase in sedentary behaviors was associated with metabolic syndrome (OR 1.28, 95% CI 1.13-1.45).[39] On the other hand, a recent randomized crossover study showed that a one-hour sitting video game session was accompanied by an increase in energy intake (+80 kilocalorie) compared to a control group, which received a relaxing session.[69]

## SLEEP

Currently, S deprivation is considered a problem of public relevance. In Mexican adults, the reported prevalence of insomnia was 39.7%[70], while 29% of adolescents reported having insomnia or difficulty sleeping.[71] Evidence suggests that a later sleep schedule may affect emotional regulation, cognitive function, academic performance, sleep duration/quality, eating behaviors, PA, and SB.[72]

An investigation of 50 observational studies conducted in different geographic regions examined the association between S and OB in adults and children. Most found a significant association between short sleep (generally <6 h per night) and an increased risk of OB.[72] Another longitudinal study reported that chronic short sleep from infancy to school age was associated with higher adiposity indicators.[73]

Short S duration has been linked to OB from various perspectives, concerning its effects on appetite, increased fatigue and prolonged exposure to the food environment, which may lead to greater food consumption.[74]

Nowadays, we live in a society characterized by work overloads, leisure activities available throughout the day, increased exposure to artificial light, and altered circadian rhythms. Short sleep duration has been associated with poor eating habits such as increased consumption of energy-rich foods, sugars, fats, and lower intake of fruits and vegetables, resulting in higher energy intake and higher BMI.[75-80]

Night eating syndrome disrupts rhythmic sleep and feeding patterns. It correlates with alterations in metabolism and OB, due to decreased leptin, phase changes of insulin, cortisol, and ghrelin, as well as reversed blood glucose changes. [81-82]

Metabolism involves circadian cycles that include the regulation of glucose, insulin and leptin, in a study of patients with circadian misalignment presented hyperlipidemia, insulin resistance, inverted cortisol rhythms, increased blood pressure, similarly, in patients with metabolic diseases such as diabetes showed alterations in the rhythms of glucose tolerance and insulin, understanding that both circadian disturbances and metabolic pathologies are bidirectional.[83-84]

On the other hand, insufficient sleep is considered a stressor, which leads to homeostatic, physiological, and behavioral changes through neuroendocrine alterations within the hypothalamic-pituitary-adrenal (HPA) axis; chronic exposure to stress is related to different health outcomes, including OB. Cortisol is the main factor that regulates the HPA axis through a negative feedback system in response to stress; however, prolonged exposure can lead to hypoactivity of the HPA axis, resulting in stress-induced feeding.[84] The main relationships of MB with OW and OB, analyzed and presented in this review, are summarized in Table 1.

***Table 1**. Relationship between movement behaviors and overweight and obesity in schoolchildren and adolescents.*[52-84]

| MB | Relationship with OW and OB |
|---|---|
| **Low physical activity** | |
| | Increased sensitivity to the appetite control system. |
| | Decrease of ghrelin. |
| | Acute exercise does not affect food intake. |
| | Vigorous exercise decreases hunger sensations. |
| **Sedentary behaviors (in front of a screen)** | |
| | Lower energy expenditure. |
| | Increased food intake. |
| | Alterations in habituation signals. |
| **Inadequate sleep** | |
| | Stress-induced eating. |
| | Increased indicators of adiposity. |
| | Increased consumption of nighttime meals. |
| | Increased consumption of energy-rich foods, sugars, and fats. |
| | Decreased intake of fruits and vegetables. |

## RECOMMENDATIONS FOR PROMOTING MOVEMENT BEHAVIORS IN SCHOOLCHILDREN AND ADOLESCENTS

Considering the information described in the previous sections, it is relevant to have strategies that promote MB in schoolchildren and adolescents in a joint and not disaggregated manner, aiming to improve their health status and prevent the development of OW and OB. Based on the COVID-19 pandemic, several general recommendations were established to promote healthy MB.[85] The recommendations established were as follows:

- Both parents and caregivers should incorporate PA into children's daily routine.
- Sedentary periods should be interrupted every 30 to 60 minutes and follow screen time recommendations.
- Maintain consistent bedtime and wake-up times, keep rooms screen-free, and avoid screen use before bedtime.
- Educators and teachers should be aware of established recommendations for movement behaviors and promote them as part of their lessons.
- Health professionals should be aware of and promote these behaviors during their care.
- Establish public policies that promote movement behaviors.
- The media should disseminate messages about the importance of an active and healthy lifestyle.

## CONCLUSION

OB is a multicausal disease that must be addressed with comprehensive approaches. According to the consulted data in this narrative review, MB unhealthy practices contribute in a disaggregated and joint manner to developing OW and OB, from the perspective of energy expenditure and control of food intake. High intensity physical activity, less time in sedentary behaviors, and optimal sleep duration offer the opportunity to integrate a program focused on health promotion and prevention of OB in schools and families.

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