
BIOLOGICAL MATURATION AND SEDENTARY BEHAVIOR IN CHILDREN AND ADOLESCENTS: A SYSTEMATIC REVIEW

MATURAÇÃO BIOLÓGICA E COMPORTAMENTO SEDENTÁRIO EM CRIANÇAS E ADOLESCENTES: UMA REVISÃO SISTEMÁTICA

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RESUMO

Este estudo tem como objetivo analisar a associação entre maturação biológica e comportamento sedentário em crianças e adolescentes. Realizou-se uma revisão sistemática em maio de 2015 nos bancos de periódicos eletrônicos da PubMed/MEDLINE, SportDiscus, Web of Science e LILACS, sem restrição de período de tempo. Foram identificados 294 artigos potencialmente relevantes e sete preencheram os critérios de inclusão. Foi possível identificar uma associação direta entre comportamento sedentário e tempo da maturação biológica. O comportamento sedentário parece aumentar com o avançar da idade cronológica e biológica em ambos os sexos. No que se refere a relação entre comportamento sedentário e timing da maturação biológica, os escolares de ambos os sexos maturados precocemente apresentaram maior comportamento sedentário. No entanto, em alguns estudos esta relação varia entre os sexos. A maturação biológica parece contribuir para o aumento do comportamento sedentário em crianças e adolescentes.

Palavras-chave: Puberdade. Estilo de vida sedentário. Estudantes.

ABSTRACT

The aim of this study was to analyze the association between biological maturation and sedentary behavior in children and adolescents. We performed a systematic review in May 2015 in the PubMed/MEDLINE, SportDiscus, Web of Science and LILACS databases, with no restriction of time. A total of 294 potentially relevant articles were identified and seven met the inclusion criteria. A direct association was identified between sedentary behavior and tempo of biological maturation. Sedentary behavior appears to increase with advancing chronological and biological age in both genders. Regarding the relationship between sedentary behavior and timing of biological maturation, greater sedentary behavior was observed in early maturing boys and girls. However, in some studies, this relationship varied between genders. Biological maturation appears to contribute to the increase in sedentary behavior in children and adolescents.

Keywords: Puberty. Sedentary life style. Students.

Introduction

The transition from childhood to adolescence is an important period of development of an individual and is characterized by various physical, emotional and behavioral transformations¹. During this phase, the process of biological maturation is an important contributor to the adoption of healthy or unhealthy behaviors in young people². Biological maturation is defined as the progression towards the mature state and consists of two components: timing and tempo³. The timing of biological maturation is considered an important risk factor for behavioral changes during this phase² and is defined as the time when a given maturational event occurs (e.g., age at menarche, growth spurt period, and appearance of secondary sex characteristics). The identification of the timing of biological maturation of an individual permits to classify him/her as an early, on-time or late maturer. In contrast, tempo is defined as the rate at which this event occurs, i.e., how slow or fast these changes manifest³.

Studies indicate that early and late maturers are more susceptible to behavioral changes that are harmful to health than those who mature on time. This finding can be explained by the fact that early and late maturers are not within their normal pattern of development and may exhibit low self-esteem and increased emotional stress that influence behavioral changes. Furthermore, early maturing boys and girls feel the need to relate to others of the same maturational age (older adolescents or adults) and adopt the same behaviors as these groups in order to be accepted².

It is known that girls reach maturity on average 2 years earlier than boys³. Thus, the analysis of the association between timing and health-related behaviors needs to take into consideration gender differences⁴. For example, sedentary activities seem to increase with advancing age in girls but not in boys⁵. It is therefore unclear whether early maturation anticipates or late maturation delays the occurrence of certain behaviors and whether these behaviors persist after adolescence⁴.

Sedentary behavior is defined as activities characterized by an energy expenditure of 1.5 METs or less^{6,7}, which are generally performed while sitting or lying down, such as screen-based activities (watching television and DVD, playing videogames, leisure-time computer use), traveling, social sedentary behavior (talking on the phone while standing or sitting), reading, doing homework, and sedentary pastime (playing a musical instrument, arts, among others)⁸.

Spending excessive time in sedentary activities may harm the physical and psychosocial health of individuals^{8,9}. In this respect, there is a growing concern regarding the adoption of sedentary behaviors by children and adolescents, especially the use of television, computer and videogames. Studies indicate that excessive sedentary behavior is associated with overweight and obesity, metabolic disorders, and cardiovascular diseases^{8,10-12}. Older adolescents represent one of the most sedentary populations, spending on average 8 hours per day in sedentary activities¹³. Understanding the patterns of sedentary behavior in childhood and adolescence permits to identify whether this behavior is stable over time and whether these negative health habits developed in childhood and adolescence carry over into adulthood^{8,14}.

Sedentary behavior, which is an important health risk factor and highly prevalent among young people, seems to be influenced by the processes of biological maturation. However, the relationship between the timing of biological maturation and sedentary behavior has not been analyzed systematically. Therefore, the present study systematically reviewed the literature to identify studies that evaluated the relationship between biological maturation and sedentary behavior in children and adolescents. To our knowledge, there is no systematic review of studies that associate sedentary behavior with biological maturation. The importance of the present study lies in the need to verify in the literature the strength and direction of the association between these two variables and to determine how sedentary behavior manifests in early, on-time and later maturers of both genders. The hypothesis of this study is that an association exists between sedentary behavior and biological maturation and this relationship varies between boys and girls. Therefore, the objective of the present study was to review and systematize the findings of studies that investigated the relationship between biological maturation and sedentary behaviors in children and adolescents.

Methods

A systematic review of the literature was performed, which identified articles describing the association between biological maturation and sedentary behavior in school

children of both genders ranging in age from 9 to 15 years. The PubMed/MEDLINE, SportDiscus, Web of Science and LILACS databases were searched in May 2015. A combination of English (Medical Subject Headings-MeSH) and Portuguese descriptors (Descritores de Ciências da Saúde - DECS) and text words were used to generate the list of citations. The search process was constructed specially for each journal database and no time limit was used in these searches.

The search strategy was based on a combination of four parameters: independent variable (biological maturation), dependent variable (sedentary behavior), population of interest (school children), and age range (9 to 15 years). The keywords for biological maturation were stratified into four subgroups: (i) "growth and development" [MeSH terms] OR growth and development [text word]; (ii) "puberty" [MeSH terms] OR puberty [text word]; (iii) "maturity" [text word] OR "maturation" [text word]; (iv) determinant factor* [text word] OR associated factor* [text word] OR correlated factor* [text word]. The keywords for sedentary behavior were: "sedentary behavior" [MeSH terms] OR sedentary behavior* [text word] OR "sedentary lifestyle" [MeSH terms] OR sedentary lifestyle [text word] OR sedentary [text word].

Each subgroup of sedentary behavior and biological maturation was used in combination with the keywords for type of sample ("students" [MeSH terms] OR student* [text word] OR high school [text word] OR school children* [text word] OR schoolchildren* [text word]) and ("child" [MeSH terms] OR child* [text word] OR "adolescent" [MeSH terms] OR adolescent* [text word] OR youth* [text word] OR teen* [text word]) to identify potentially relevant studies. The boolean operator AND was used to combine the four groups in the search. The asterisk (*) was used to capture all variations in the suffix of the root word.

The articles were selected using the Cochrane methodology of systematic reviews¹⁵. The search of the electronic journal databases and the selection of titles, abstracts and articles were performed independently by two researchers who rigorously followed the inclusion and exclusion criteria defined. The methodological quality of each selected article was analyzed individually and then discussed by the two researchers until a consensus was reached. In the case of discordance, the opinion of a third evaluator was requested.

The inclusion criteria in this review were: (i) studies published in indexed journals; (ii) school children aged 9 to 15 years; (iii) individuals of both genders; (iv) cross-sectional or longitudinal design; (v) Portuguese, English or Spanish language; (vi) studies addressing associated factors and determinants of sedentary behavior. The exclusion criteria were: (i) samples including subjects whose age was outside the established range (9 to 15 years); (ii) samples including pregnant adolescents; (iii) adolescents with hormonal diseases; (iv) adolescents with some type of syndrome; (v) absence of sedentary behavior and/or biological maturation analyzed as variables in the study. These criteria were selected to increase the comparability between studies.

First, analysis was performed based on the titles of the manuscripts. When the title or abstract was not informative, i.e., there were doubts regarding the content of the article, the full-text article was retrieved to ensure that important studies were not excluded from the systematic review. Duplicate titles were selected and the repeated title was excluded from the selection. After selection of the titles, the evaluators read the titles independently and discussed them until a consensus was reached for selection of the abstracts. The same procedure was performed with the abstracts to select the articles. Thus, after analysis of the titles and abstracts, all full-text articles were obtained and included if they met the inclusion criteria. The researchers then read the full texts. The reviews of all selected articles were examined to identify other publications that could be included in the review.

Results

The literature search identified 294 potentially relevant articles in the journal databases investigated. According to the inclusion criteria, after analysis of the titles and exclusion of 21 titles of duplicate articles, 35 articles were selected for reading of the abstracts. After evaluation of the abstract, the full text of 8 articles was read and 7 were selected. Only one study was excluded since it did not contain the variable of interest (biological maturation). No study was included based on the references of the articles read and added to the review (Figure 1).

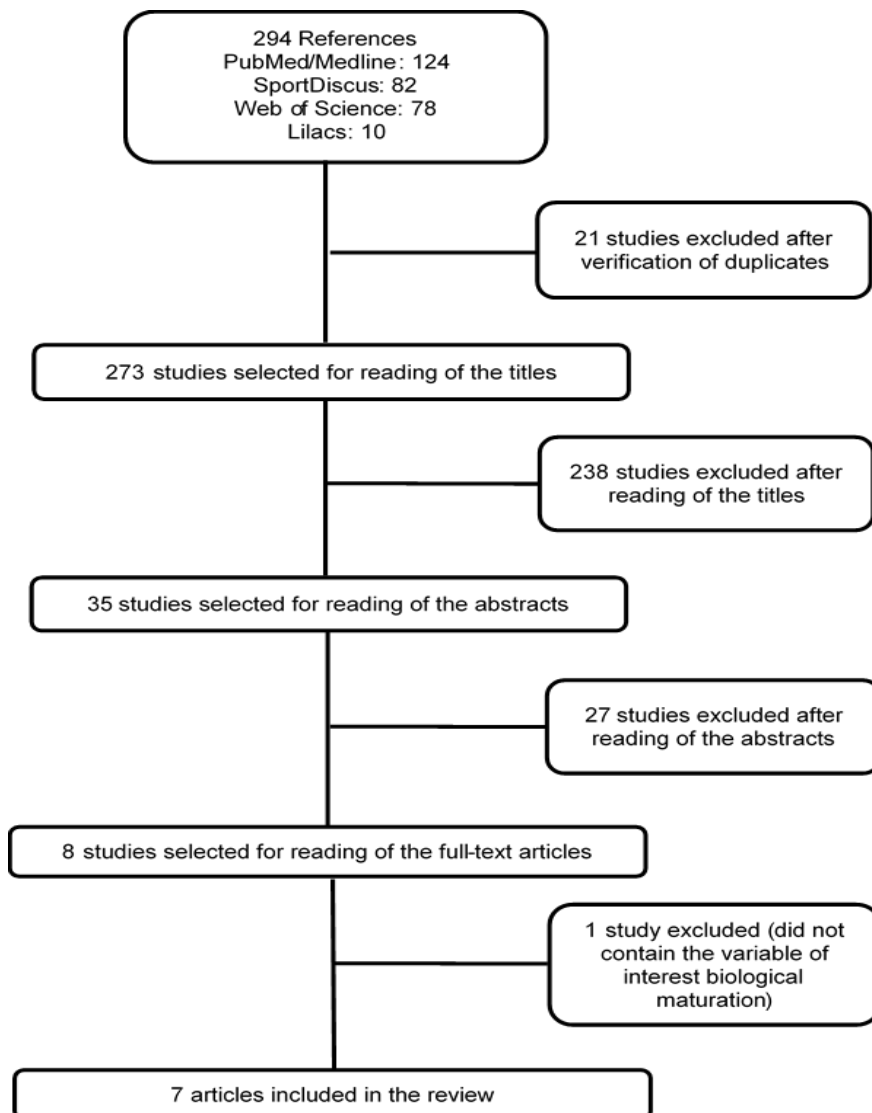


Figure 1. Flow chart of the strategy used for selection of the studies.

Source: The authors.

Table 1 shows the general information of the seven articles included in the systematic review.

Table 1. Studies investigating the association between sedentary behavior and biological maturation in school children.

Reference	Sample	Study design	Measure of SB	Measure of BM	Association between SB and BM
Murdey <i>et al</i> (2004)	120 school children (10-15 years)	C	Self-reported	Secondary sex characteristics	Greater SB in early, late and postpubertal ♂ and ♀ compared to prepubertal ones; greater SB in late pubertal and postpubertal ♂ and ♀ compared to prepubertal and early ones.
Brodersen <i>et al</i> (2005)	4,320 school children (11-12 years)	C	Self-reported	PDS	Greater SB in early maturing ♀
Murdey <i>et al</i> (2005)	83 school children (10-15 years)	L	Self-reported	Secondary sex characteristics	Greater SB in ♂ of more advanced pubertal level
Saygin <i>et al</i> (2007)	853 prepubertal and pubertal school children	C	Self-reported	Defined previously	Greater SB in pubertal ♀
Van Jarsveld <i>et al</i> (2007)	5,863 school children (11-12 years)	L	Self-reported	PDS	Greater SB in early maturing ♂ and ♀
Rodrigues <i>et al</i> (2010)	302 school children (13-16 years)	C	Accelerometry	PPAH	Maturation is an important predictor of SB in ♂
Micklesfield <i>et al</i> (2014)	381 school children (11-12 and 14-15 years)	C	Self-reported	Tanner stages	Greater SB in ♂ and ♀ with advanced pubertal development

SB, sedentary behavior; BM, biological maturation; C, cross-sectional; L, longitudinal; PDS, Pubertal Development Scale; PPAH, percentage of predicted adult height; ♂, boys; ♀, girls; NI: not informed.

Source: The authors.

Different methods were used to evaluate biological maturation and sedentary behavior. Two studies had a longitudinal design^{4,16} and the design was cross-sectional in the remaining studies¹⁷⁻²¹.

The instruments used to assess sedentary behavior were variable, with most studies employing self-reported measures. Only one study used accelerometry as a measure of SB²⁰. Different instruments were used to classify biological maturation. Secondary sex characteristics^{16,17} and the Pubertal Development Scale^{4,18} were the most commonly used tools. The other studies used the percentage of predicted height²⁰, Tanner stages²¹, and evaluation of previously defined biological maturation¹⁹. The ages of the samples were heterogeneous, involving children and adolescents aged 10 to 16 years.

Three of the seven studies included in the present review employed control variables in the statistical analyses, including sleep time^{16,17}, age, ethnicity and socioeconomic level⁴.

A direct association was observed between sedentary and tempo of biological maturation, with sedentary behavior increasing with advancing chronological and biological age in both genders. With respect to the timing of biological maturation, early maturing girls exhibited greater sedentary behavior^{18,19}. In the studies of Murdey *et al.*¹⁶ and Machado Rodrigues *et al.*²⁰, sedentary behavior was greater in early maturing boys, while in the studies

of Murdey et al.¹⁷, van Jaarsveld et al.⁴ and Micklesfield et al.²¹, early maturing boys and girls engaged in more sedentary behaviors.

Discussion

According to the studies reviewed, a direct association exists between tempo of biological maturation and sedentary behavior, i.e., sedentary behavior increases with advancing chronological and biological age in both genders. In the study of Machado Rodrigues et al.²⁰, the average daily time spent in sedentary behaviors increased with age in boys by 28.8 min/day and in girls by 15.1 min/day. Murdey et al.¹⁷, comparing prepubertal students with pubertal and postpubertal students, observed greater sedentary behavior among more advanced participants (pubertal and postpubertal), suggesting that sedentary behavior increases during adolescence.

The transition from childhood to adolescence is a critical period for behavioral changes, such as the change from active leisure-time activities to activities that involve more sedentary habits including television watching, videogames and/or computer use¹⁸. However, according to Murdey et al.¹⁷ studying school children from North West Leicestershire, United Kingdom, the greater sedentary time during this phase is not due to the choice of sedentary activities over physical activities, but to the lack of availability of more active leisure-time activities at night, i.e., during this phase, adolescents spent many hours of the day in sedentary activities, maintaining this behavior from day to night. One possible explanation for this behavior is parental support and the influence of television or internet, which favor sedentary activities.

The studies analyzing the association of sedentary behavior with timing of biological maturation (early, on time or late) demonstrated greater sedentary behavior in early maturing adolescents of both genders^{4,17,21}. However, in some studies this relationship varied between genders. In the studies of Brodersen et al.¹⁸ and Saygin et al.¹⁹, early maturing girls exhibited greater sedentary behavior, while in the studies of Machado Rodrigues et al.²⁰ and Murdey et al.¹⁶, maturation was an important predictor of sedentary behavior in boys, i.e., boys with advanced pubertal development engaged in more sedentary behaviors. Taken together, these findings highlight the inconsistency of the results and the need for further studies evaluating the relationship between biological maturation and sedentary behavior. These divergences might be related to methodological differences between studies, including the sample selection procedures, measurement difficulties and variability, and classification of the two variables.

An increase in sedentary time during pubertal development may have implications for future chronic diseases in this population²¹. According to van Jaarsveld et al.⁴, maturation timing seems to exert a persistent impact in adolescence, which actually renders maturation a marker of high risk for sedentary behavior, i.e., early maturing adolescents are at risk of unhealthy behaviors. This suggests that early maturation may be a cause of, or is at least a risk marker for, differences in lifestyle.

One possible explanation for the negative impact of early maturation on health behaviors is that, although physically developed, the adolescent may be psychologically immature and has no cognitive abilities to resist social pressure from his/her friends who tend to perform more sedentary behaviors. Furthermore, early maturing girls and boys tend to have older friends and acquire similar behaviors in order to comply with the rules of certain groups and gain participation and identity. Puberty produces a transformation in the relations between parents and their children and the adolescent's timing of maturation thus stimulates the desire to cut family ties to engage in a deviant behavior⁴. However, studies addressing the

association between timing of biological maturation and sedentary behavior are potentially difficult because of the confounding effect of age and other factors that might influence the school environment.

According to Machado Rodrigues et al.²⁰, gender differences related to sedentary behavior were attenuated when maturation was controlled, suggesting that maturity plays an important role in adolescent behavior. In other words, the effect of gender on sedentary behavior was attenuated and nonsignificant when biological maturation was statistically controlled. Thus, biological maturation is a source of variation for gender differences in sedentary behavior during adolescence.

However, although differences in the timing and tempo of biological maturation may contribute to gender differences in sedentary behavior, it is rather the combination of social, psychological, physical and physiological changes associated with biological maturation that underlie these differences and not only the state of maturity. In the study of Machado Rodrigues et al.²⁰, weight, height, chronological age and somatic maturation explained 5 to 12% of the variance in sedentary behavior. The role of psychosocial factors in the increase of sedentary behavior in adolescents may be related to social demands such as doing homework, employment, dating, and the pressure from parents who consider this behavior to be safer³.

The physical and physiological changes associated with puberty and the growth spurt in girls include changes in body composition (increased fat deposition) and proportions (breast development and broadening of the hips), discomfort related to the regular menstrual cycle and a reduction in blood hemoglobin levels, which compromise motor and physiological performance and favor the acquisition of more sedentary leisure-time activities. In addition, advanced maturation in girls is associated with lower motor skill proficiency, as well as with a lower capacity to carry weights and perform resistance exercises. Additionally, the increase in daily duties, work at home or the transition from school to work, might play an important role increasing the time spent in sedentary activities^{3,20}. In contrast, the physical changes that occur in boys, such as height and body weight gain, an increase in the proportion of lean mass and widening of the shoulders, are beneficial for the participation in physical activities since they result in a more adequate physical contribution to the success in many types of physical activities, particularly those that emphasize speed, power and strength²².

Sleep time^{16,17}, age, ethnicity and socioeconomic level⁴ were considered control variables in the studies. Shorter sleep duration has been associated with more time spent in front of the television, watching television at night, and videogame and internet use in students^{23,24}. Sleeping can be considered a sedentary activity since its energy expenditure is 0.9 METs²⁵. Thus, sleep time needs to be controlled so that it is not quantified as sedentary behavior in studies.

Likewise, sedentary behavior can differ depending on the age and ethnic background of the student. The older the student, the greater the tendency to engage in low-energy activities, especially television, computer and video game use as leisure-time option. Older students usually do not feel very attracted to physical activities and replace them with more sedentary activities²⁶. Furthermore, cultural, historical, linguistic, racial, artistic and religious aspects inherent to the populations studied can influence sedentary behavior⁷, and ethnicity is therefore an important control variable.

Higher levels of sedentary behavior are observed among students of elevated socioeconomic level^{26,27}. These students probably have better access to computers and videogames and parents of higher education level more easily acquire electronic devices for their children, thus increasing the prevalence of sedentary behaviors among these students²⁸.

Consequently, socioeconomic level influences sedentary behavior in students and needs to be controlled.

Body composition, body image^{20,21} and chronological age²⁰ may be related to differences in behavioral choices and may partially explain the relationship between biological maturation and sedentary behavior. Thus, studies performing mediation analysis between biological maturation and sedentary behavior are necessary to identify factors that mediate this relationship.

Among the limitations of the studies analyzed, it was observed that none of them was conducted in Latin America; most were European studies and two were conducted in South Africa and Turkey. The sample size of the majority of the studies was small and the methods for selection of the samples were not reported. Some studies used assessment instruments of sedentary behavior without validity and reliability testing to demonstrate their legitimacy. It is also important to highlight the difficulty in comparing the studies because of the different methods used to evaluate biological maturation and sedentary behavior.

Regardless of the contradictions found in this review, the present findings support the use of maturational aspects as an important variable in studies aimed at a better understanding of sedentary behaviors in school children. In addition, this study provides guidelines to further investigate this association (maturational aspect x sedentary behavior), including improvement in study designs such as the use of control variables, mediation and inclusion of maturational timing to elucidate differences between genders.

Final considerations

Based on this review, the scientific evidence suggests that biological maturation is directly associated with sedentary behavior, i.e., sedentary behavior tends to increase with advancing chronological and biological age in both genders. However, this relationship varied between studies, indicating inconsistency in the results found. In some studies early matures showed higher sedentary behavior, irrespective of gender, while in others the gender was an important moderator of this relationship.

Biological maturation seems to play a prominent role in increased sedentary behavior in school children. It is recommended that health promotion efforts in childhood and adolescence designed to encourage a reduction in sedentary behavior do not only take into consideration the chronological age of individuals, but also maturational changes that are responsible for behavioral changes in children and adolescents. Considering the small number of articles found, further studies evaluating the association between sedentary behavior and biological maturation are necessary. Finally, standardization of the criteria used to determine biological maturation and sedentary behavior in children and adolescents is important to facilitate the comparison between studies.

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