

## Physical activity and adolescent sexual maturity: a systematic review

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**Abstract** *The objective was to verify the association between sexual maturation and physical activity during adolescence. A systematic review of articles published between 2008 and 2018 was conducted using the following databases: PubMed/Medline, SciELO, Web of Science, Scopus, Lilacs, and BVS Adolec Brasil. The following descriptors and keywords were used in English and Portuguese: adolescent, sexual maturation, survey, questionnaire, and physical activity. The literature search retrieved 806 articles. Twelve articles were included after applying the selection criteria. Level of physical activity was highest in the initial stage of sexual maturation. Levels of physical activity appear to decrease with advancing sexual maturation status. There is no consensus about the association between sexual maturation and physical activity levels among adolescents within the literature reviewed by this study. Further research is needed to investigate whether this relationship exists and professionals involved in healthcare for adolescents should take effective steps to combat physical inactivity.*

**Key words** *Adolescent, Sexual maturation, Survey, Questionnaire, Physical activity*

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## Introduction

A number of epidemiological studies have sought to measure levels of physical activity in the population and the main factors associated with non-adherence to physical activity<sup>1-6</sup>. The World Health Organisation (WHO) recommends that adolescents should engage in 300 minutes of moderate - and vigorous - intensity aerobic physical activity per week in a combination of muscle-strengthening and flexibility activities<sup>7,8</sup>. This practice contributes to healthy growth and development and fosters the adoption of good life-style habits in adult life, helping to prevent chronic degenerative diseases<sup>9</sup>.

Physical inactivity is associated with an increase in body fat and therefore a greater risk of heart disease and other health problems such as diabetes *mellitus*, high blood pressure, osteoporosis, and some types of cancer in later life<sup>10,11</sup>. Obesity is a multifactorial disease that affects all age groups and is currently considered a global epidemic<sup>10-14</sup>. The prevalence of overweight and obesity is high among adolescents and evidence shows that excess body fat can adversely affect quality of life<sup>12-15</sup>. Neto and collaborators stress that excess body fat mass intensifies insulin resistance, causes blood vessel disorder and stiffness, and adversely affects blood pressure levels<sup>14</sup>. Within this context, the leading risk factor for cardiovascular diseases among adolescents is excess body fat<sup>13</sup>.

It is important to draw attention to the high rates of physical inactivity among adolescents<sup>4-16</sup>. In this respect, the prevalence of the practice of physical inactivity varies widely in some studies<sup>5-6-17</sup>. Studies have explored environmental, social, economic, nutritional, psychological, maturational factors in an attempt to understand the determinants of low levels of physical activity among young people<sup>4-18</sup>. More specifically, some studies have focused on the association between biological maturation and level of physical activity<sup>19-22</sup>.

In this respect, evidence suggests that practice of physical activity is more related to biological age than chronological age. Adolescents in the same age group may be at different stages of pubertal development and show different levels of physical activity. Sexual maturation may therefore be a key factor influencing practice of physical activity during adolescence<sup>20-23-24</sup>. However, the evidence on this association remains inconclusive<sup>25-26</sup>.

In view of the above, the objective of this study was to investigate and assess the association

between sexual maturation and level of physical activity in the current literature on this topic using the following review question: *Is there an association between sexual maturation and level of physical activity among adolescents?* By gaining a better understanding of this association it is hoped that this study will contribute to the development of new outcome indicators to guide healthy practices and health policies and interventions aimed at promoting adolescent health.

## Methods

A systematic literature review was conducted using electronic databases to identify publications that specify the association between sexual maturation and level of physical activity among adolescents. The review encompassed international and national studies that answered the review question, regardless of sex of the study sample. A search of articles published between 2008 and 2018 was undertaken by three independent researchers.

The following bibliographic databases were used: *PubMed/MEDLINE* (Medical Literature Analysis and Retrieval System Online), *SciELO* (Scientific Electronic Library Online), *Web of Science*, *Scopus*, *LILACS* (Latin American and Caribbean Literature on Health Sciences); and *BVS Adolec Brasil* (Virtual Adolescent Health Library). The following descriptors and keywords were used in Portuguese and English with the Boolean operators *or* and *and*: *adolescente* (adolescent) and *maturação sexual* (sexual maturation) and *inquérito* (survey) and *questionnaire* (questionnaire) and *atividade física* (physical activity), using the PECO (Population, Exposure, Comparator, and Outcomes) approach<sup>27</sup>. The term *exercício físico* (physical exercise) was also used as an analogue for *atividade física* (physical activity).

The following inclusion criteria were used: epidemiological studies (cross-sectional, case-control, cohort, and clinical trials) and articles examining the relationship between maturation and level of physical activity among adolescents of both sexes published between 2008 and 2018. Case studies, literature reviews, research reports, technical reports, projects, government documents, grey literature, and studies involving animals were excluded.

The following combinations of *MeSH* (*Medical Subject Headings*) descriptors and keywords were used in English: *physical activity OR physical*

*exercise AND sexual maturation AND surveys and questionnaires AND adolescent; physical activity OR physical exercise AND sexual maturation AND adolescent.* The following combinations of DeCS Science and Health Descriptors descriptors and keywords were used in Portuguese: *atividade física OR exercício físico AND maturação sexual AND inquérito e questionaire AND adolescente; atividade física OR exercício físico AND maturação sexual AND adolescente.*

The data was collected on 12 July 2018. After the initial search, a filter was applied to the retrieved articles restricting the search to articles published in all languages in the last 10 years (January 2008 to July 2018) involving the 10 to 19 year age group.

Each of the articles retrieved after applying the filter was screened by title and abstract against the inclusion and exclusion criteria and review question and duplicate articles were removed. The review process (identification, screening, eligibility, and inclusion of retrieved articles) was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) protocol<sup>28</sup>.

Article selection and assessment was performed autonomously by three researchers (CG Campos, FM Carlos, LA Muniz). The full versions of the selected articles were then assessed against the inclusion criteria. Any discrepancies between the three researchers were resolved by group discussion in order to reach consensus based on the inclusion and exclusion. The strength of scientific evidence of each study was graded based on the categories developed by the Agency for Healthcare Research and Quality (AHRQ)<sup>29</sup>.

## Results

The initial literature search retrieved 806 records, 51 of which were selected after applying the filter and screening. The reading of the full version of the selected articles resulted in a final selection of 12 articles (Figure 1).

The samples of the selected studies, all of which were international, totaled 13,120 individuals. Six of the studies (50%) were cross-sectional and six were (50%) longitudinal. Chart 1 presents key information on the selected 12 articles.

With regard to age group, the selected studies encompassed the three stages of adolescence: early adolescence (ages 10 and 13), middle adolescence (ages 14 and 16 years), and late adolescence (ages 17 and 20)<sup>29</sup>. The large majority of

the studies (91,7%; n = 11) focused on early adolescence<sup>20,30,24,31,38</sup>. None of the studies evaluated the period as a whole, as defined by the WHO<sup>39</sup>.

Five studies identified an inverse association between sexual maturation and physical activity<sup>20-30-31-34-35</sup>, while two reported a direct association, showing that more mature girls and boys and those in more advanced stages of sexual maturation tended to be more physically active<sup>24-33</sup>. Three studies found that changes in physical activity are more influenced by sex than maturation<sup>19,32,37</sup>. Knowles and collaborators showed that a decrease in overall physical activity levels was not influenced by maturational status<sup>36</sup>. Kristensen and collaborators also reported that maturity was not related to physical activity<sup>38</sup>.

The studies used various instruments to assess maturational status, including: the Tanner-scale (self-assessment)<sup>35</sup>; percentage of predicted adult stature (the Khamis-Roche method), used to predict mature height from current age<sup>19,40</sup>; and the pubertal development scale<sup>20,24,32,36</sup>. Questions were also asked to determine age at menarche (the status quo method)<sup>30</sup> and somatic biological maturity status<sup>31</sup>.

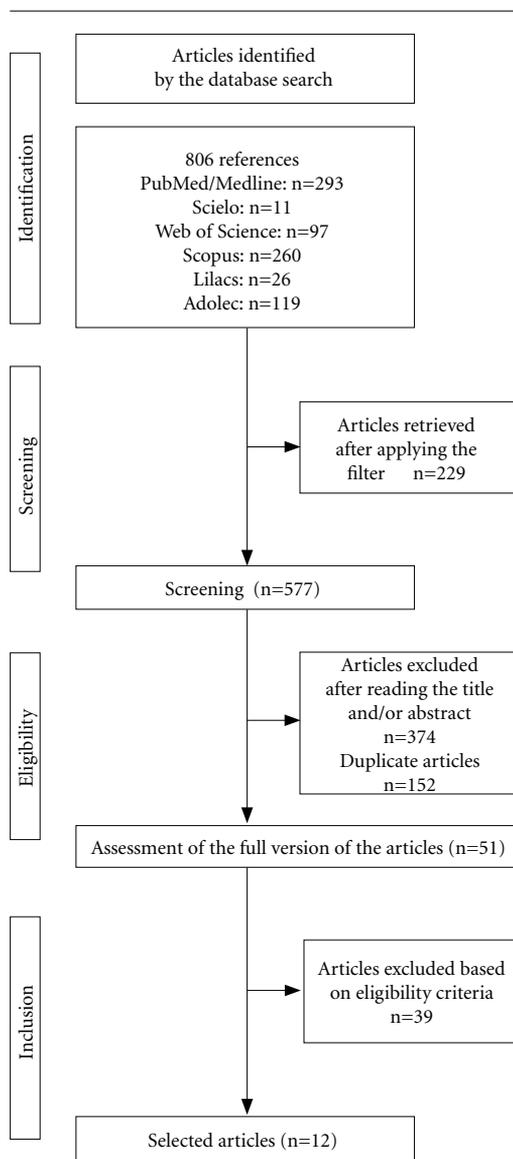
The following instruments were used to measure physical activity: Physical Activity Questionnaire for Adolescents (PAQ-A)<sup>19-41</sup>; Physical Activity Questionnaire for Older Children (PAQ-C)<sup>20-42</sup>; accelerometer<sup>31-33-38</sup>; questionnaires<sup>32-34-35-37</sup>; Seven-Day Physical Activity Recall<sup>30</sup>; and Physical Activity Questionnaire for Children<sup>24-36</sup>.

A wide range of tools and parameters were used to assess biological maturation and physical activity and various types of statistical analysis were performed to determine the association of interest.

## Discussion

The findings show that there is no consensus about the association between sexual maturation and level of physical activity within the reviewed literature.

Benítez-Porres and collaborators found no evidence of an association between sexual maturation and level of physical activity. However, they found a statistically significant association between physical activity and sex ( $p < 0,05$ ), showing that boys were more physically active than girls<sup>19</sup>. Most of the studies that compared sexes showed that boys were more physically active than girls; however, the factors related to this



**Figure 1.** Flow diagram of the article selection process: identification, screening, eligibility, and inclusion of scientific articles in the systematic review in accordance with PRISMA<sup>23</sup>.

Source: The authors.

difference are not well described in the reviewed literature<sup>19-31-32-37</sup>.

Finne and collaborators concluded that early maturing boys, and girls with irregular menstruation, were more likely to be inactive in comparison to their peers (OR = 2,20, CI 95% = 1,36-3,56

and OR = 1,71, CI 95% = 1,06-2,75, respectively)<sup>35</sup>, while a longitudinal study demonstrated that a decrease in overall physical activity levels over 12 months was not influenced by maturational status<sup>36</sup>. Likewise, Kristensen and collaborators found no link between maturational status and physical activity<sup>38</sup>.

In a study with South Korean adolescents, Lee Eun-Young and collaborators found an inverse relationship between biological maturity and physical activity, showing that individuals with advanced pubertal status were less physically active ( $p < 0,001$ )<sup>20</sup>. Another study comparing practice of physical activity and sedentary behavior in 1,324 pre and post menarche girls showed that pre menarche girls practiced physical activity more regularly than post menarche girls ( $3,5 \pm 1,9$  times/week compared to  $3,0 \pm 1,7$  times/week,  $p < 0,001$ ). This difference was statistically significant. However, this study found no evidence of a significant difference in time spent per week doing physical activity between the two groups<sup>30</sup>.

Guinhouya and collaborators measured biological maturity using the Prediction of Age of Peak Height Velocity method, observing a correlation between total time spent doing physical activity and maturation in girls. The study showed a significant increase in level of physical activity among preadolescent girls up to the predicted age at peak height velocity ( $p = 0,028$ ). However, the same study found a pronounced decrease in level of physical activity after children reached the age at peak height velocity, demonstrating that late-maturing adolescents showed low levels of physical activity ( $p = 0,06$ )<sup>31</sup>.

The same authors also found a statistically significant correlation between time spent doing moderate-to-vigorous physical activity and predicted age at peak height velocity standardized by sex ( $p = 0,016$  in boys and  $p = 0,155$  in girls). With regard to overall physical activity (light, moderate, and vigorous), boys were significantly more active than girls ( $p < 0,0001$ )<sup>31</sup>. In this respect, a study conducted by Cairney and collaborators showed that participation in physical activity began to decline after age 12 in both sexes and that the rate of decline was greater in girls than in boys<sup>32</sup>.

Davison and collaborators investigated the relation between sexual maturation and physical activity in 178 adolescents in the United States using three measures of pubertal development: the Pubertal Development Scale, Tanner's criteria, and estradiol levels. The study concluded that early maturing girls were less physically active<sup>25</sup>.

**Chart 1.** Studies on the relationship between maturation and physical activity.

Author/ Year/ Location	Sample size and age group	Study design	Measure of physical activity	Measure of maturation status	Association between maturation and physical activity	Scientific evidence
Cumming et al., 2008. <sup>37</sup> United Kingdom	n = 186 adolescents (13 - 14 years)	Cross- sectional	Self-reported	Percentage of predicted adult height	Physical activity decreased with in creasing biological age.	Level 4
Kristensen et al., 2008. <sup>38</sup> Europe	n = 1,318 children/ adolescents (8 - 10; 14 -16 years)	Cross- sectional	Accelerometer	Self-reported	No significant association.	Level 4
Knowles et al., 2009. <sup>36</sup> Europe	n = 150 girls (12,79+/- 0,31 years)	Longitudinal	Self-reported	Pubertal Development Scale	No significant association.	Level 3
Finne et al., 2011. <sup>35</sup> Germany	n = 6,813 adolescents (11 - 17 years)	Cross- sectional	Structured interview	Tanner Scale	Early-maturers more likely to be less physically active.	Level 4
Erlandson et al., 2011. <sup>34</sup> Northern Germany	n = 187 adolescents (8 - 15 years)	Longitudinal	Self-reported	Prediction of Age of Peak Height Velocity	Physical activity decreased with advancing sexual maturation status.	Level 3
Guinhouya et al., 2012. <sup>31</sup> France	n = 253 adolescents (10 years)	Longitudinal	Accelerometer	Skeletal maturity	Physical activity decreased with increasing biological age.	Level 3
Cairney et al., 2014. <sup>32</sup> Northern Germany	n = 2,100 adolescents (11 - 14 years)	Longitudinal	Self-reported	Prediction of Age of Peak Height Velocity	Physical activity decreased with increasing biological age among girls.	Level 3
Fawkner et al., 2014. <sup>24</sup> Scotland	n = 208 girls (11.8 ± 0.4 years)	Longitudinal	Self-reported	Pubertal Development Scale	Physical activity in creased with advancing sexual maturation status.	Level 3
Lätt et al., 2015. <sup>33</sup> Estônia	n = 265 boys (10 - 14 years)	Cross- sectional	Accelerometer	Self-reported	Physical activity increased with advancing sexual maturation status.	Level 4
Marques et al., 2016. <sup>30</sup> Portugal	n = 1,324 girls (10 - 13 years)	Cross- sectional	Structured interview	Structured interview	Physical activity decreased with advancing sexual maturation status.	Level 4
Lee Eun- Young et al., 2016. <sup>20</sup> South Korea	n = 236 adolescents (average 13.6 years)	Cross- sectional	Pedometer Self- reported	Pubertal Development Scale	Physical activity decreased with advancing sexual maturation status.	Level 4
Benítez-Porres et al., 2016. <sup>19</sup> Spain	n = 80 adolescents (14 - 19 years)	Longitudinal	Self-reported	Percentage of predicted adult height	Boys more physically active than girls.	Level 3

Source: The authors.

The inverse was shown by a school-based study with 4,320 adolescents conducted by Simon and collaborators. Using the Pubertal Development Scale and a physical activity questionnaire, the authors concluded that advanced puberty was associated with higher levels of physical activity<sup>26</sup>.

Regular practice of physical activity appears to decline with increasing age in both sexes. With increasing age adolescents are more likely to reduce daily energy expenditure from physical activity. School work, work, access to technology, and the increasing lack of security in cities, are the main social and behavioral factors that lead to inactive life styles. Similarly, the lack of open public spaces for physical activity and the fact that most of these spaces are devoted to children and early teens contribute to low levels of physical activity in middle and late adolescents<sup>9-37</sup>.

Furthermore, early adolescents tend to have more time to practice physical activity, since they spend less time doing school work and working. Likewise, degree of family dependence / independence can also influence levels of physical activity during the different stages of adolescence as younger adolescents tend to be more influenced by their parents. Adolescents are therefore more likely to practice more physical activity in their younger teens, showing a decline in levels of physical activity as they become more independent<sup>4,9,37</sup>.

However, longitudinal study that assessed girls at baseline, six months and 18 months found statistically significant differences in physical activity between maturity groups, showing that early maturers were more physically active<sup>24</sup>. Similarly, Kemper and collaborators and Simon and collaborators suggest that early maturers are more physically active and that levels of physical activity were in line with international recommendations<sup>26,43</sup>. Lätt and collaborators also investigated differences in levels of physical activity between early, average, and late maturing boys, showing that average and late maturing boys practiced more physical activity than early maturing boys<sup>33</sup>.

The most widely used instruments for measuring physical activity were questionnaires, accelerometers, and pedometers<sup>19,20,24,30-32</sup>. Guedes and collaborators suggest that the best methods for assessing physical activity and energy expenditure are laboratory parameters, including doubly labeled water and calorimetry. The latter measures produce high quality results and good classification accuracy. However, these procedures are costly, require trained professionals and well-

equipped laboratories, and do not differentiate between physical activity intensity, duration, and frequency<sup>44</sup>.

Accelerometers and pedometers have been satisfactorily used in epidemiological studies with adolescents and school children, since the motion sensors can detect practice and levels of physical activity. However, their use is infeasible in studies with large samples<sup>44,45</sup>. Questionnaires are therefore the most commonly used instruments in national studies. Despite their limitations and issues relating to subjectivity and underestimation / overestimation, questionnaires are key tools because they are relatively inexpensive, easy to use with large samples, require little training to administer, and offer a way to gather large amounts of data which can be used to inform policy making<sup>46,47</sup>.

The studies highlighted gender-related differences in levels of physical activity. This may be due to differences in physical development between sexes, whereby girls tend to develop earlier than boys<sup>32,48</sup>. Public health interventions aimed at adolescents should therefore focus on biological age and sex rather than chronological age<sup>49</sup>.

The use of a wide range of instruments to measure physical activity and maturational status hinders possible comparisons, inferences, and conclusions regarding international and national recommendations<sup>50-52</sup>.

In addition, only one study adopted Tanner's criteria<sup>35</sup>. Tanner defined stages of the maturation process based on external primary and secondary sex characteristics, such as the development of pubic hair, genitals, and breasts. The classification can be assessed clinically by qualified health professionals or self-assessed, the latter being the most commonly used alternative in population studies<sup>53</sup>.

The Tanner scale is widely used in the field of adolescent health in Brazil, is made available in the Handbook of Adolescent Health, and recommended by the Ministry of Health for assessing sexual maturation<sup>53-54</sup>. Numerous factors influence the way adolescents understand their adolescence and how it affects their choices about being physically active<sup>55</sup>. Engagement in regular physical activity is therefore influenced by a combination of biological, social, psychological, and environmental factors and characterized by a complex behavioral phenotype. This behavioral model is sufficiently dynamic to interact physiologically with sexual and biological maturational development, leading to an increase in physical inactivity during adolescence<sup>56</sup>.

Decreased physical activity during sexual maturation can be observed in all mammals. This phenomenon may be related to little-understood changes in the underlying endocrine processes that modulate adolescent growth and sexual maturation. Maturation of the hypothalamic-pituitary-gonadal axis mediates the release of hormones. Subsequent neural reorganization and changes in maturity status and in the body may influence physical activity<sup>57</sup>.

Another study puts forward a hypothesis for understanding the determinants of levels of physical activity, suggesting the existence of an inherent control / regulatory center for physical activity or energy expenditure by the central nervous system. Based on this thesis, decreased physical activity during adolescence may be related to stages of development, when the body requires additional energy to fuel growth, implying that the metabolism uses a tactical energy rationing mechanism. However, further research is needed to investigate this condition in adolescents<sup>57-59</sup>.

It is also important to mention that major changes take place in the brain during adolescence. Neurochemical and neurotransmitter changes can induce feelings of insecurity, fear, curiosity, and excitement, mood changes, an inability to perceive risks, impulsiveness, and the seeking of new experiences<sup>60-61</sup>. In addition, analytical understanding and reflective behavior skills only fully develop towards the end of adolescence and challenging behaviors and risk-taking tend to diminish in the post pubertal phase. Within this context, certain studies suggest physical activity is greater in the final phase of adolescence, when neurophysiological and psychological conditions are fully developed and adolescents are better

prepared to take care of their body and their physical health<sup>24,33,62,63</sup>.

Dopamine is a neurotransmitter that is capable of altering normal motor activity. The number of dopamine receptors decreases during adolescence, suggesting a decline in daily physical activity in this phase. Similarly, changes occur in the reward and motivation system of the adolescent's brain. Activities that in childhood provided pleasure become boring during adolescence, leading the adolescent to seek new behaviors, rewards, and experiences, and therefore require greater stimulus to achieve the levels of pleasure experienced in the prepubertal phase<sup>60-64</sup>.

One of the limitations of this study is the dearth of articles on this topic. The absence of national studies, lack of unification of protocols, criteria, and standardized instruments for measuring sexual maturation and level of physical activity in the selected studies, and the varying concepts of adolescence in the literature, are factors that hinder the formation of a consensus regarding the association between sexual maturation and physical activity. Further research is therefore needed to gain a deeper understanding of this association.

## Conclusion

The findings show that there is no consensus about the association between sexual maturation and physical activity with in the current literature and further research is there fore required to investigate possible associations. New knowledge in this area is important to enable professionals involved in healthcare for adolescents to take effective steps to tackle physical inactivity.

## Collaborations

CG Campos, FM Carlos, LA Muniz, WC Bila, V Damasceno, MCC Romano e JA Lamounier also contributed to the elaboration of this work.

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