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INFLUENCE OF OBESITY ON GROWTH STAGES AND BONE MATURATION OF CERVICAL VERTEBRAE IN CHILDREN AND ADOLESCENTS: A LITERATURE REVIEW

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ADMINISTRATIVE INFORMATION

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Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 4 October 2025 and was last updated on 4 October 2025.

INTRODUCTION

Review question / Objective General Objective • To determine the influence of obesity on the stages of growth and bone maturation in cervical vertebrae in children and adolescents according to a literature review.
Specific Objectives
1. To identify the local and systemic factors in obesity that act as mechanisms altering the normal growth pattern and cervical bone maturation.
2. To describe the mechanism of action by which obesity generates alterations: accelerating metabolism and ossification, thereby affecting bone transformation.
3. To analyze the results of published studies where these variables have been compared, demonstrating their clear association with maturation and ossification stages.

Rationale This research has a theoretical rationale, as its purpose is to update the knowledge related to obesity and the growth stages of cervical vertebrae in children and adolescents. In this regard, recent information is compiled, providing more detailed and up-to-date data available for future research. From a methodological perspective, the rationale lies in the systematic search of bibliographic information from recognized scientific databases. In terms of practical rationale, its importance lies in contributing relevant information that makes it possible to identify potential alterations in skeletal growth. Likewise, it gains significance by establishing the existing influence between the study variables, namely obesity and the growth stages of cervical vertebrae during childhood and adolescence. Finally, from a clinical standpoint, the findings of this research are useful for the scientific community, students in the field of oral and maxillofacial radiology, orthodontics, and maxillofacial orthopedics, as well as for healthcare professionals who access this information for diagnostic and therapeutic purposes.

Condition being studied Childhood and adolescent obesity is a multifactorial condition characterized by excessive body fat accumulation

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that may impair health and development. It is diagnosed through the body mass index (BMI), adjusted for age and sex, according to World Health Organization (WHO) reference standards. In addition to its well-known metabolic and cardiovascular consequences, obesity has been linked to accelerated skeletal maturation and premature ossification.

This condition may influence the growth and development of craniofacial structures, including the cervical vertebrae, which are commonly assessed through lateral cephalometric radiographs in orthodontics and oral radiology. The cervical vertebral maturation (CVM) method allows for the estimation of skeletal maturity by evaluating morphological changes in vertebrae C2, C3, and C4.

Recent evidence suggests that children and adolescents with obesity present more advanced stages of cervical bone maturation compared with their chronological age, likely due to hormonal and metabolic alterations involving leptin, insulin, and insulin-like growth factor 1 (IGF-1). Understanding this condition is crucial to avoid misinterpretation of skeletal age and inappropriate therapeutic decisions in orthodontic and dentofacial orthopedic practice.

METHODS

Search strategy A systematic electronic search was conducted according to the PRISMA 2020 guidelines. The databases PubMed (via MEDLINE), Scopus, SciELO, and LILACS were explored to identify articles published between 2010 and 2025.

The literature search, data collection, and risk-of-bias assessment were carried out during 2025.

The following MeSH and free-text terms were used in different combinations with Boolean operators:
(Obesity OR Overweight OR "Body Mass Index") AND
("Bone Development" OR "Bone Maturation" OR "Skeletal Maturity" OR "Growth Stages") AND
("Cervical Vertebrae" OR "Cervical Vertebral Maturation" OR CVMS) AND
(Child OR Children OR Adolescent OR Adolescents OR Teenagers)
Inclusion criteria:

Observational studies (cross-sectional, case-control, and cohort).

Participants aged 8 to 14 years in active skeletal growth.

Evaluation of the relationship between obesity (measured by BMI) and cervical vertebral maturation through lateral cephalometric radiographs.

Articles published in English or Spanish.

Exclusion criteria:

Reviews, editorials, animal studies, or investigations not addressing the relationship between obesity and cervical maturation.

Duplicates or inaccessible full texts.

The search process was supplemented with a manual review of reference lists and the identification of relevant articles not indexed in the primary databases.

Participant or population The population included in the selected studies consisted of children and adolescents aged 8 to 14 years who were in active stages of skeletal growth and development. Participants of both sexes were evaluated in the original studies using lateral cephalometric radiographs to determine the stages of cervical vertebral maturation. The included studies excluded individuals with systemic diseases, endocrine disorders, or congenital anomalies that could affect bone development.

Intervention In the included studies, the intervention or exposure corresponded to the presence of obesity or overweight, determined using the body mass index (BMI) adjusted for age and sex according to international or national reference standards. This condition was analyzed in each study as an associated factor influencing variations in the growth stages and bone maturation of cervical vertebrae.

Comparator In the analyzed studies, the comparator group consisted of children and adolescents with normal weight for their age and sex, according to BMI reference standards. These participants were considered as the control or reference group, compared with overweight or obese subjects, to assess differences in the stages of cervical bone maturation.

Study designs to be included Observational studies, including cross-sectional, case-control, and cohort designs, were included to evaluate the relationship between the degree of obesity and the stages of cervical vertebral bone maturation in children and adolescents. Reviews, case reports,

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editorials, and experimental studies were excluded.

Eligibility criteria Original research articles were included if they met the following criteria:

Population of children and adolescents aged 8 to 14 years in growth stages.

Assessment of overweight or obesity using body mass index (BMI) adjusted for age and sex.

Evaluation of cervical vertebral maturation stages using lateral cephalometric radiographs.

Publications written in English or Spanish between 2010 and 2025.

Exclusion criteria were animal studies, narrative reviews, clinical trials, and articles without full-text access or with insufficient data for analysis.

Information sources The searches were performed in the electronic databases PubMed (MEDLINE), Scopus, SciELO, and LILACS, complemented by a manual review of the reference lists of selected articles and relevant gray literature. MeSH terms and free-text keywords were combined using Boolean operators.
The selection, data extraction, and risk-of-bias assessment were conducted following the PRISMA 2020 guidelines and the Joanna Briggs Institute (JBI) critical appraisal tools for observational studies (cross-sectional, cohort, and case-control). Only studies published in English or Spanish between 2010 and 2025 were included.

Main outcome(s) The findings showed that obesity influences cervical bone maturation by accelerating ossification stages in children and adolescents, likely due to increased levels of leptin, insulin, and IGF-1 acting on growth centers. Most studies reported a positive association between higher BMI and skeletal maturity, as evaluated through the cervical vertebral maturation (CVM) method.

However, there was methodological heterogeneity among the studies, with differences in obesity classification and maturation assessment scales. The evidence suggests that obesity may lead to advanced skeletal maturation, with clinical implications in orthodontics, oral radiology, and pediatric endocrinology.

Additional outcome(s) In addition to the relationship between obesity and cervical bone maturation, some studies suggested a potential influence of sex and biological age on the variation of maturation stages. Overweight or obese girls tended to show more advanced skeletal maturation compared to boys.

The review also identified common methodological limitations, such as small sample sizes, lack of adjustment for endocrine factors, and differences in BMI classification across countries. These findings highlight the need to standardize evaluation methods and to conduct longitudinal studies to confirm the causal relationship between obesity and cervical maturation.

Data management Data management was carried out through a structured process of study selection and data extraction. All identified articles were imported into Microsoft Excel and organized according to the search strategy. Duplicates were removed, and inclusion and exclusion criteria were applied.

Extracted data included: author, year, country, study design, sample size, age range, BMI assessment method, cervical vertebral maturation (CVM) method, and main findings.
The information was verified by two independent reviewers, and a third evaluator supervised the process and resolved discrepancies.
The final data were qualitatively synthesized following the recommendations of the Joanna Briggs Institute (JBI).

Quality assessment / Risk of bias analysis Methodological quality and risk of bias were assessed using the Joanna Briggs Institute (JBI) critical appraisal tools for observational studies. Three specific checklists were applied according to the study design:

Analytical cross-sectional studies

Cohort studies

Case-control studies

Each study was independently evaluated by two reviewers, and disagreements were resolved by a third evaluator. The assessed items included clarity of selection criteria, measurement of exposure and outcomes, control of confounding factors, and adequacy of statistical analysis.

Studies were classified as having low, moderate, or high risk of bias based on the number of affirmative responses to the JBI checklist items.

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Strategy of data synthesis A qualitative (narrative) synthesis was performed due to heterogeneity among studies regarding design, obesity definitions, and methods for assessing cervical bone maturation.
Results were organized in data extraction tables, summarizing methodological characteristics, sample size, sex distribution, body mass index (BMI), cervical vertebral maturation (CVM) method, and main findings.
Trends were compared across studies with low, moderate, and high risk of bias to identify consistent patterns. Findings were interpreted in the context of endocrine and orthodontic evidence, highlighting clinical implications and methodological limitations.

Subgroup analysis A comparative analysis by sex and age reported in the included studies showed that skeletal maturation tends to occur earlier in obese girls.
No meta-analysis was conducted due to study heterogeneity, but consistent trends were identified suggesting that higher BMI is associated with accelerated cervical bone maturation stages.
This subgroup analysis allowed the identification of biological and clinical differences that should be confirmed through longitudinal studies with larger samples.

Sensitivity analysis A formal sensitivity analysis was not performed, as the included studies differed in design and measurement criteria. However, the consistency of the results was verified by comparing the main findings of studies with low and moderate risk of bias, showing a coherent trend toward accelerated skeletal maturation in obesepatients.

Language restriction English and Spanish.

Country(ies) involved Peru.

Other relevant information This systematic review was conducted as part of the academic requirements to obtain the Specialist Degree in Oral and Maxillofacial Radiology at the Instituto Latinoamericano de Altos Estudios en Estomatología (ILAE). The study followed the PRISMA 2020 guidelines for systematic reviews and applied the Joanna Briggs Institute (JBI) tools for critical appraisal and risk-of-bias assessment.

The protocol included the definition of the PICO framework, comprehensive searches in international databases, independent evaluation by three reviewers, and qualitative synthesis of the findings.

The results provide evidence on the influence of obesity on cervical bone maturation in children and adolescents, with relevant implications for radiologic diagnosis and orthodontic treatment planning.
No external funding or conflicts of interest were reported.

Keywords Obesity, Body Mass Index, Skeletal Maturation, Cervical Vertebrae, Cephalometry, Child, Adolescent.

Dissemination plans The results of this systematic review will be disseminated through the INPLASY platform and are expected to be subsequently published in a peer-reviewed scientific journal indexed in Scopus or PubMed, to contribute to the understanding of the influence of obesity on cervical bone maturation. Additionally, the study will be presented at the Instituto Latinoamericano de Altos Estudios en Estomatología (ILAE) as part of the requirements to obtain the Specialist Degree in Oral and Maxillofacial Radiology.

Contributions of each author
Author 1 - Gaby Romero Morales - The author participated in all stages of the systematic review: topic conception, methodological design, literature search and selection, data extraction and analysis, risk of bias assessment, and writing of the final manuscript.
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