

# Prevalence and early predictors of Metabolic Syndrome Among Adolescents:

## An Integrative review

R. Dhanalakshmi<sup>1</sup>, Dr. R. Sudha<sup>2</sup>, Dr. Prema Janardan<sup>3</sup>, Dr. M. Deepa<sup>4</sup>, Ms. P. Umalakshmi<sup>5</sup>, Ms. I. Kavitha<sup>6</sup>

<sup>1</sup>PhD Research Scholar, VHS-M. A. Chidambaram College of Nursing, Chennai  
The Tamil Nadu Dr. M.G.R Medical University, Chennai

<sup>2</sup>PhD Research Guide, VHS-M. A. Chidambaram College of Nursing,  
The Tamil Nādu Dr. M.G.R Medical University, Chennai

<sup>3</sup>PhD Research Co-Guide, VHS-M. A. Chidambaram College of Nursing, Chennai,  
The Tamil Nādu Dr. M.G.R Medical University, Chennai

<sup>4</sup>Professor, VHS-M. A. Chidambaram College of Nursing,  
The Tamil Nādu Dr. M.G.R Medical University, Chennai, Chennai

<sup>5</sup>Professor, VHS-M. A. Chidambaram College of Nursing, Chennai,  
The Tamil Nādu Dr. M.G.R Medical University, Chennai

<sup>6</sup>Lecturer, VHS-M. A. Chidambaram College of Nursing, Chennai,  
The Tamil Nādu Dr. M.G.R Medical University, Chennai

Corresponding author: R. Dhanalakshmi [ghanalakshmikumaran@yahoo.co.in](mailto:ghanalakshmikumaran@yahoo.co.in)

**How to cite this article:** R. Dhanalakshmi<sup>1</sup> Dr. R. Sudha<sup>2</sup> Dr. Prema Janardan<sup>3</sup>, Dr. M. Deepa<sup>4</sup>, Ms. P. Umalakshmi<sup>5</sup>, Ms. I. Kavitha<sup>6</sup>. Prevalence and early predictors of Metabolic Syndrome Among Adolescents. Int J Drug Deliv Technol. 2026;16(83s):353-367. DOI: 10.25258/ijddt.16.83s.41.

### Introduction

Metabolic syndrome (MetS) is a multifaceted group of metabolic abnormalities involving impaired regulation of protein, fat and carbohydrate metabolism. The world is confronting a growing challenge of overweight and obesity, particularly among children and adolescents (Zhang B, Shi H, Cai W, Yang B and Xiu W, 2025). Metabolic disorders such as hypertension, obesity, hyperglycemia, and dyslipidemia, together identified as metabolic syndrome, substantially increase the likelihood of developing non-communicable diseases (NCDs). Cardiovascular diseases rank among the most prevalent (NCDs) in adulthood and are the primary cause of mortality worldwide. (Kathrin Günther, 2025).

Pediatric obesity, previously viewed as a concern limited to high-income countries, has now grown to epidemic levels across middle and low-income nations as well, affecting populations in urban slums and rural communities alike (Vaman Khadilkar et al., 2023). The prevalence of obesity in children continues to grow, resulting in metabolic syndrome and increasing economic burden for health systems (Alvarez et al., 2020).

The WHO estimates, based on 2020 data, state that the global prevalence of Mets among adolescents was approximately 4.8%. Concurrently, nearly 39% of the global population is facing challenges of being overweight, which is a concern due to a significant increase in children and adolescents. It was closely associated with modifiable risk factors, including changes in food consumption, inadequate physical activity, and increased screen time, which were further entrenched after the post-COVID era. The concern regarding Mets in adolescence stems from the fact that as they transition into adulthood, they may become highly susceptible to various cardiovascular disorders and type 2 diabetes. This study aimed to conduct an integrative review on the prevalence and early risk factors of metabolic syndrome among adolescents.

## Research Question

What is the research evidence available on the prevalence and risk factors of MetS among adolescents?

## Design

An integrative review approach proposed by Whittemore & Knafl (2005) was used to synthesise evidence for practice.

## Search Methods

Literature was searched from online databases such as PubMed and Google Scholar. In addition, articles were identified from the reference lists of included articles and Google. The main search terms used in the databases were prevalence, metabolic syndrome, adolescents and risk factors. Articles published from 2020 onwards were included. PICO format is used. P-Adolescents (10–19 years), I- Prevalence and risk factors of Metabolic syndrome, C-Adolescents without those risk factors, or a healthy reference group and O - Prevalence and risk factors of metabolic syndrome.

## Inclusion/Exclusion Criteria Inclusion Criteria:

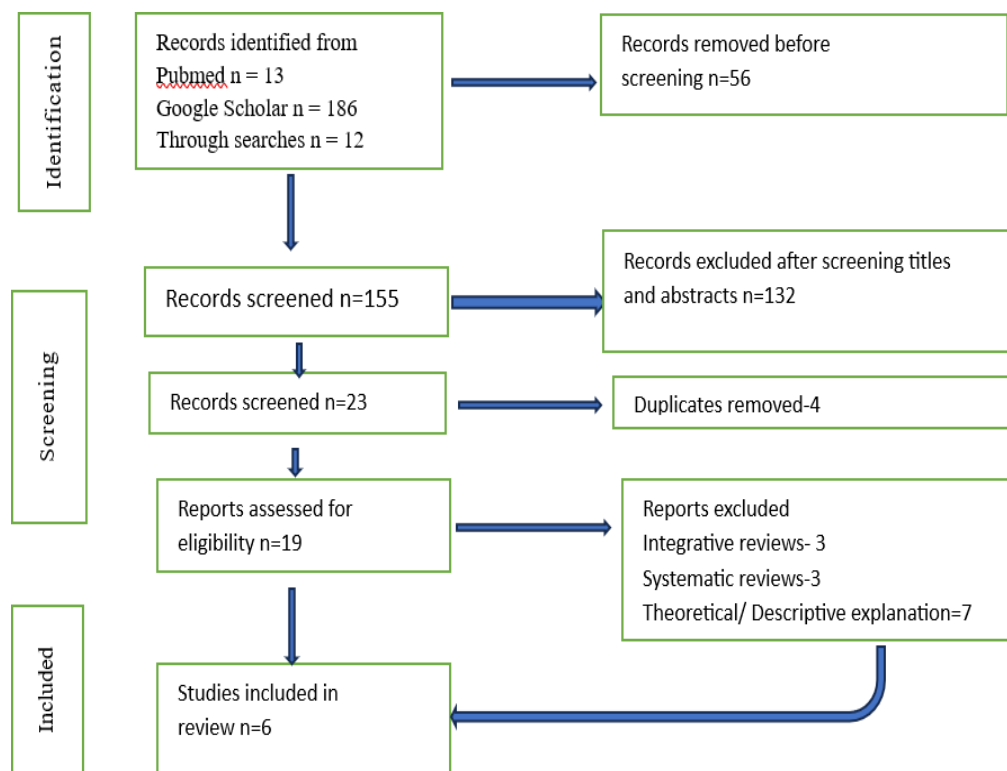
Studies conducted among adolescents and articles available in the English language only were included. The final search was conducted on 6th April 2026. Articles published from 2020 to till date and free full-text articles were included. All types of study design other than reviews were included. There were no restrictions placed based on study design and the number of participants in the study.

## Exclusion Criteria:

Secondary sources were excluded. Editorials, opinions, reviews, letters, adult-only studies, intervention studies without baseline prevalence data, conference abstracts, and editorials were excluded.

## Selection of Studies

All database search results were exported to the Mendeley reference manager software version 2.117.0. With the help of the software, duplicate search results were deleted. Next, a two-step selection process was undertaken. In step one, two independent reviewers (RD, RS) scanned the titles and abstracts of all articles reporting on the prevalence of metabolic syndrome. In step 2, full-text articles were screened by the three independent reviewers(RD,RS &PJ) to determine their eligibility to be included in the review. In the end, fully eligible articles were selected for further analysis (Figure 1).



**Figure 1: Diagram showing the article selection process****Data Extraction, Analysis and Synthesis****Table 1: Characteristics of studies included in the review**

| S<br>l<br>.<br>N<br>o | Aut<br>hor<br>(Ye<br>ar)<br>Cou<br>ntry                                                         | Aim                                                                                                                                                                                    | Desig<br>n,<br>Partic<br>ipants<br>(Sam<br>ple<br>Size)<br>and<br>Settin<br>g                                                                                                                                  | Varia<br>ble<br>Meas<br>urem<br>ent                                                                                                                                                     | Ma<br>in<br>Ou<br>tco<br>me<br>s                                                                                                                              | Main<br>Findin<br>gs                                                                                                                                                                                      |
|-----------------------|-------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1                     | Sen<br>gott<br>aiya<br>n<br>Pala<br>nive<br>letal<br>.,<br>(202<br>5)<br>Sout<br>h<br>Indi<br>a | To<br>deter<br>mine<br>the<br>risk<br>facto<br>rs<br>unde<br>rlyin<br>g the<br>deve<br>lop<br>ment<br>of<br>child<br>hood<br>and<br>adol<br>esce<br>nt<br>obes<br>ity,<br>and<br>deter | Cross-<br>section<br>al<br>survey<br>,<br>screen<br>ed<br>3,195<br>school<br>childr<br>en and<br>adoles<br>cents<br>from<br>lower<br>and<br>lower-<br>middl<br>e<br>socio-<br>econo<br>mic<br>groups<br>. From | Socio<br>demo<br>graphi<br>c,<br>dietar<br>y,<br>lifesty<br>le,<br>anthro<br>pomet<br>ric,<br>clinic<br>al,<br>and<br>metab<br>olic<br>param<br>eters.<br>(meas<br>ureme<br>nt<br>tool) | Pre<br>val<br>enc<br>e<br>and<br>Ris<br>k<br>fac<br>tor<br>s<br>obe<br>sity<br>and<br>ove<br>rw<br>eig<br>ht<br>and<br>pre<br>dic<br>tor<br>s of<br>me<br>tab | The<br>preval<br>ence<br>of<br>overw<br>eight<br>was<br>14.2%<br>and<br>obesit<br>y was<br>7.6 %<br>in<br>rural<br>areas<br>respect<br>ively,<br>and in<br>urban<br>areas,<br>the<br>preval<br>ence<br>of |

|  |  |                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                           |  |                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  | mine<br>the<br>pred<br>ictor<br>s of<br>meta<br>bolic<br>synd<br>rom<br>e<br>(Met<br>S) in<br>child<br>hood<br>and<br>adol<br>esce<br>nt<br>obes<br>ity<br>and<br>its<br>meta<br>bolic<br>alter<br>ation<br>s in<br>the<br>Sout<br>h<br>Indi<br>an<br>popu<br>lation | this<br>pool,<br>by<br>rando<br>m<br>cluster<br>sampli<br>ng<br>techni<br>que,<br>166<br>overw<br>eight<br>and<br>obese<br>indivi<br>duals<br>and 38<br>contro<br>l<br>partici<br>pants<br>in<br>Madur<br>ai<br>distric<br>t,<br>Tamil<br>Nadu,<br>South<br>India<br>were<br>selecte<br>d |  | oli<br>c<br>syn<br>dro<br>me | overw<br>eight<br>was<br>slightl<br>y<br>increas<br>ed to<br>16.1<br>and<br>preval<br>ence<br>of<br>obesit<br>y was<br>8.8 %,<br>respect<br>ively.<br>The<br>age<br>distrib<br>ution<br>of the<br>control<br>and<br>study<br>group<br>is 12.3<br>± 1.5<br>and<br>13.0 ±<br>1.9<br>years<br>with a<br>male-<br>to-<br>female<br>ratio<br>of<br>1.4:1<br>and<br>1.6:1,<br>respect<br>ively.<br>This<br>study<br>founde<br>d<br>dense<br>food<br>and<br>screen<br>time in<br>the<br>obese<br>group<br>compa |
|--|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|  |  |  |  |  |  |                                                                                                                                                                                                                                                                                                              |  |  |  |  |  |                                                                                                                                                                                                                                                                                                              |
|--|--|--|--|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  |  |  |  |  | red to the control group. The average outdoor play time was 1.5 hr per day in the control group and less than 0.5 h per day in the obese group. the waist-to-height ratio (WHtR) optimum cutoff value of 0.56, has 95 % sensitivity and 84 % specificity, effectively identifying MetS cases. HOM A-IR (Home |  |  |  |  |  | ostatic Model Assessment of Insulin Resistance) optimum cutoff value of 2.25, has 96 % sensitivity and 72 % specificity. The triglyceride-glucose index (TGI) optimum cutoff value of 4.51, has 92 % sensitivity and 88 % specificity indicating a strong balance between correctly identifying positive and |
|--|--|--|--|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|  |  |  |  |  |  |                                |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |    |
|--|--|--|--|--|--|--------------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|----|
|  |  |  |  |  |  | negati<br>ve<br>MetS<br>cases. |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | </ |
|--|--|--|--|--|--|--------------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|----|

|  |  |  |  |  |  |                                                                                                                                                                                                                                                                                                                                   |  |  |  |  |  |                                                                                                                                                                                                                                                                                                                                  |
|--|--|--|--|--|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  |  |  |  |  | soft drinks or carbonated drinks over water when thirsty. This study also evaluated the predictive power of the associated factors for pediatric metabolic syndrome using receiver operating characteristic (ROC) analysis. The ROC curve showed an area under the curve of 0.926 (95% CI: 0.891-0.961, $p < 0.001$ ), indicating |  |  |  |  |  | ing high predictive power. The optimal cutoff point for the prediction of variables was determined to be 0.5. the findings suggest that the factors identified in multivariate analysis strongly predict MetS in children. Only those significant variables in the multivariable logistic regression were selected to create the |
|--|--|--|--|--|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|   |                                         |                                                                                   |                                                                                                                                                                                                                              |                                                                                                                                                                                                                   |                                                   |                                                                                                                                                                                                                                                                                                                           |
|---|-----------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|   |                                         |                                                                                   |                                                                                                                                                                                                                              |                                                                                                                                                                                                                   |                                                   | final model which included the male gender, not using the bike or not walking to school, not participating in organized physical activity, not performing MVP A, or not playing for three or more days a week, not taking three meals a day, not prefer to drink water while thirsty, screen time for more than two hours |
|   |                                         |                                                                                   |                                                                                                                                                                                                                              |                                                                                                                                                                                                                   |                                                   |                                                                                                                                                                                                                                                                                                                           |
| 3 | Arej Alowfi et al., (2021) Saudi Arabia | To determine the prevalence and risk factors of MetS in Saudi Arabian adolescents | Cross-sectional study was conducted in two female National Guard schools (Um Kalthom Intermediate School and Zainab Bint Jahsh Secondary School) in Jeddah, Saudi Arabia, N= 172 female students, (age range of 12–19 years) | Demographic data, physical measurements (blood pressure, weight, height, body mass index (BMI) and waist circumference (WC), and biochemical measurements (fasting plasma glucose and triglycerides, high density | Prevalence and risk factors of metabolic syndrome | daily, and night sleep for less than eight hours.                                                                                                                                                                                                                                                                         |
|   |                                         |                                                                                   |                                                                                                                                                                                                                              |                                                                                                                                                                                                                   |                                                   | Of the 172 female adolescents, 24 (13.75%) were overweight, 20 (11.63%) were obese, and 3 (1.74%) were underweight. High-fasting plasma glucose (n = 85, 49.41%) and high waist circumference (n = 74, 43.02%) were the most common risk factors of MS among                                                              |

|    |                             |                                                                                                                                                      |                                                                                                                  |                                                                                                                                                                                    |                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                             |                                                                                                                                                      |                                                                                                                  | lipoprotein (HDL), and low-density lipoprotein)                                                                                                                                    |                                                                              | female adolescents. The overall prevalence of MetS was 7% (n = 12/172). MetS is more common among those who are obese or among those with a BMI that falls at the 95 <sup>th</sup> percentile (n = 6/20, 30.0%) (p < 0.05) as compared to those who are overweight with a BMI that falls within the 85 <sup>th</sup> to <95 <sup>th</sup> percentiles (n = 2/24, 8.33%). Furthermore, 3.20% of the sample (n = 4/125) with normal BMI were also diagnosed with MetS. |
| 4. | Diego et al., (2025) Mexico | To evaluate the predictive risk factors associated with the prevalence of metabolic syndrome (MetS) in adolescents from the western region of Mexico | An analytical cross-sectional study was conducted with a sample of 516 adolescents aged 10 to 17 years in Mexico | General data, socio-demographic characteristics, history of addictions, level of physical activity, current diagnoses of cardiovascular conditions, ongoing treatments, and family | predictive risk factors associated with the prevalence of metabolic syndrome | The MetS prevalence was 17.2% among adolescents. One out of every two adolescents with obesity presented with MetS. Abdominal obesity and dyslipidemia were the most common components. Predictors of                                                                                                                                                                                                                                                                |

|  |        |                                                    |                                                                                                                                                                                                                                         |                                                                                                                                                                       |                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                    |
|--|--------|----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |        |                                                    |                                                                                                                                                                                                                                         |                                                                                                                                                                       | histor<br>y of<br>cardio<br>metab<br>olic<br>diseas<br>es<br>Anthr<br>opom<br>etric<br>data,<br>blood<br>pressu<br>re,<br>and<br>bioch<br>emica<br>l<br>deter<br>minati<br>ons<br>were<br>obtain<br>ed<br>trigly<br>ceride<br>–<br>gluco<br>se<br>index<br>(TyG<br>index)   | MetS<br>includ<br>ed<br>male<br>sex,<br>early<br>adoles<br>cence,<br>waist-<br>to-<br>height<br>ratio<br>(WHt<br>R) ><br>0.5,<br>increas<br>ed<br>body<br>fat<br>percen<br>tage,<br>and<br>TyG<br>Index<br>> 4.68<br>(IR).<br>In the<br>sex-<br>specifi<br>c<br>analysi<br>s, a<br>WHtR<br>> 0.5<br>and IR<br>were<br>associ<br>ated<br>with<br>MetS<br>in<br>female<br>adoles<br>cents.<br>In<br>male<br>adoles<br>cents,<br>IR and<br>body<br>fat<br>percen<br>tage<br>were<br>associ<br>ated |                                                                                                                                                                                                                                                                                    |
|  | 5<br>. | Pei-<br>Wen<br>et al.,<br>(202<br>2)<br>Tai<br>wan | To<br>inve<br>stiga<br>te<br>the<br>laten<br>t<br>clust<br>erin<br>g<br>struc<br>ture<br>and<br>its<br>stabi<br>lity<br>for<br>Met<br>S<br>duri<br>ng<br>adol<br>esce<br>nce,<br>and<br>asse<br>ss<br>the<br>anth<br>ropo<br>metr<br>ic | A<br>comm<br>unity-<br>based<br>repres<br>entativ<br>e<br>adoles<br>cent<br>cohort<br>(n =<br>1516)<br>condu<br>cted in<br>South<br>ern<br>Taiwa<br>n<br>school<br>s. | Socio<br>demo<br>graphi<br>c<br>factor<br>s and<br>lifesty<br>le<br>behav<br>iors<br>from<br>adoles<br>cent<br>partici<br>pants<br>and<br>their<br>parent<br>s.<br>Anthr<br>opom<br>etric<br>param<br>eters,<br>includ<br>ing<br>height<br>,<br>weigh<br>t,<br>hip<br>circu | Inc<br>ide<br>nce<br>and<br>re<br>mis<br>sion,<br>risk<br>fac<br>tor<br>s of<br>me<br>tab<br>oli<br>c<br>syn<br>dro<br>me                                                                                                                                                                                                                                                                                                                                                                       | Amon<br>g<br>adoles<br>cents<br>with<br>MetS-<br>negati<br>ve at<br>baselin<br>e, 3.2–<br>4.4%<br>had<br>incide<br>nce of<br>MetS<br>after<br>2.2<br>years.<br>Amon<br>g<br>adoles<br>cents<br>with<br>MetS-<br>positiv<br>e at<br>baselin<br>e, 52.0–<br>61.9%<br>experi<br>enced |

|   |                             |                                                                                           |                                                                                                           |                                                                                                                                                                                               |                                  |                                                                                                                                                                                                                                                                                                                     |  |  |  |  |  |                                                                                                                                         |
|---|-----------------------------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|-----------------------------------------------------------------------------------------------------------------------------------------|
|   |                             | and clinical metabolic determinants for MetS transformation . conducted in Taiwan schools |                                                                                                           | mference, waist circumference (WC), systolic BP (SBP) , and diastolic BP (DBP ), Venous blood samples forTG and HDL-C concentrations, FPG levels were assessed using a glucose oxidase method |                                  | MetS remission, and 38.1–48.0% experienced MetS persistence. Increased systolic BP (SBP) was associated with a high MetS incidence risk, while decreased levels of SBP and glucose were associated with MetS remission. Compared with adolescents with a normal metabolic status at baseline, those with an initial |  |  |  |  |  | abdominal obesity had 15 % greater risk and and increased triglycerides level had 5.7% greater risk of metabolic syndrome respectively. |
| 6 | Sowmya et al., (2022) India | To explore the prevalence of metabolic syndrome among adolescents in India                | A population-based study children and adolescents (0–19 years), conducted across all 29 states of India . | Waist circumference, blood pressure, triglycerides, HDL cholesterol and glucose                                                                                                               | Prevalence of metabolic syndrome | The prevalence of MetS was 5.2% among adolescents. The prevalence rate was high in males (5.7%) compared to female (4.7%) . Urban adolescence showed a significantly higher                                                                                                                                         |  |  |  |  |  |                                                                                                                                         |

|  |  |  |  |  |  |                                                                                                                                                                                                                                                                                                                 |
|--|--|--|--|--|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |  |  |  |  |  | prevalence (7.9%) than rural adolescents (4.2%).<br>.<br>Wealthier households reported an 8.3% prevalence compared to 2.4% in poorer households. The prevalence of individual risk factors was 11.9% had central obesity, 15.4% had high blood pressure, 26.0% had hyperglycemia, 31.9% had low HDL-cholesterol |
|--|--|--|--|--|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|  |  |  |  |  |  |                                                   |
|--|--|--|--|--|--|---------------------------------------------------|
|  |  |  |  |  |  | erol and 3.7% high fasting glucose, respectively. |
|--|--|--|--|--|--|---------------------------------------------------|

## Results

### Characteristics of the studies

The literature search generated 211 articles. After analyzing abstracts and titles, eliminating duplicates, the number of articles was reduced to 23. Subsequently, full-text articles were reviewed. After eliminating integrative reviews, systematic reviews, and articles involving participants other than adolescents, the final number of articles that fulfilled the inclusion criteria was six. These six articles were included for final review. These studies were conducted in India (n=3), Saudi Arabia (n=1), Mexico (n=1) and Taiwan (n=1)). The total sample size from these studies was 4,588 adolescents. With regard to study design, four were cross sectional design, one was a case-control study, and two were cohort study designs. Four out of six studies were conducted in schools, and the remaining two studies were conducted in the general population.

### Evidence on the prevalence and risk factors of Metabolic syndrome among adolescents

All six studies have reported the prevalence and risk factors of adolescents as outcome variables.

- Out of six studies, one study reported the incidence, risk and remission of metabolic syndrome after 2.2 years. (Pei-Wen et al.)
- One study reported that the prevalence is 30% high in overweight and 8.33% in obese adolescents (Aneej et al., 2021)
- Two studies have reported that prevalence is high in urban areas (7.9%) than rural areas (4.2%) (Sengottaian et al., 2025 & Sowmya et al 2022)
- A Mexican study reported that 17.2% prevalence among Mexican American adolescents, and 1 out of 2 adolescents with obesity presented with metabolic syndrome. (Diego et al., 2025)
- Two studies reported that prevalence was higher in males (5.7%) than with females (4.7%) (Diego Ortega et al., 2025 & Sowmya et al., 2022).
- One study has reported the prevalence is more common (30%) with those with a BMI at the 95th percentile, also found out even

adolescents with normal (3.2%) BMI were diagnosed with metabolic syndrome (Aneej et al., 2021)

- An Indian study reported that the prevalence was 5.5% among Indian adolescents. Also, the study reported that 11.9% had central obesity, 15.4% had high blood pressure, 26% had hypertriglyceridemia, 31.9% had low HDL cholesterol, and 3.7% had high fasting glucose. (Sowmya et al., 2022)
- One study reported that increased systolic blood pressure was associated with a high incidence risk, while decreased levels of systolic blood pressure and glucose were associated with remission. Also reported that those with initial abdominal obesity (15%) and increased triglyceride level (5.7%) have a greater risk for persistent risk of metabolic syndrome abnormality. (Pei Wen et al., 2022).
- One study reported that the waist-to-hip optimum cut-off value of 0.56 having 95% sensitivity and 84% specificity to identify metabolic syndrome. Also, reported that the triglycerides optimum cut off value of 4.51, which has 92 % sensitivity and 88 % specificity, indicating a strong balance between correctly identifying positive and negative MetS cases. (Sengottaian et al., 2025)
- Two studies reported that decreased outdoor physical activity, screen time usage more than 2 hrs and preference of soft drinks or carbonated drinks were the risk factors (Sengottaian et al., 2025; Sreeja et al., 2024)
- Skipping meals, sleeping less than 8 hrs at night and eating with a screen on were the risk factors (Sreeja et al., 2024)
- Obese, overweight, high fasting plasma glucose and high waist circumference were the most common risk factors among female adolescents (Aneej et al., 2021)

### Discussion

The results of the integrative review show that the prevalence of metabolic syndrome is high in overweight and obese adolescents. Review findings reported that it is high in males and in urban slums. Furthermore, one out of two American adolescents with obesity presented with metabolic syndrome. Recent evidence supports these findings. a strong association between obesity and metabolic syndrome, with obese adolescents showing a significantly higher likelihood of developing metabolic abnormalities (Munku Song et al., 2024).

Metabolic syndrome is more commonly observed in adolescents with a BMI at or above the 95th percentile, central obesity, elevated blood pressure, hypertriglyceridemia, low HDL cholesterol, increased fasting glucose, and greater waist circumference. Evidence also suggests that early abdominal obesity and elevated triglyceride levels are strong predictors of persistent metabolic abnormalities. Furthermore, specific anthropometric and biochemical cut-off values have been identified as useful screening tools; the waist-to-hip ratio and triglyceride levels demonstrate good sensitivity and specificity in identifying metabolic syndrome. A cross-sectional study conducted among obese adolescents reported that central obesity indicators such as waist-to-hip ratio were significantly associated with metabolic syndrome, with higher values conferring nearly twice the risk of developing the condition (Widjaja et al., 2023). The study also confirmed that elevated triglyceride levels, low HDL cholesterol, and increased blood pressure were strongly linked with metabolic syndrome components in adolescents. Decreased outdoor physical activity, screen time usage more than 2 hrs, skipping meals, sleeping less than 8 hrs and preference for soft drinks or carbonated drinks were the risk factors for metabolic syndrome.

### Discussion

The results of the integrative review reported a wide range of prevalence rate, Sowmya et al. (2022) reported an overall prevalence of 5.5% among Indian adolescents, a figure broadly consistent with community-level estimates in general adolescent populations. In contrast, Diego Ortega et al. (2025) reported a substantially higher prevalence of 17.2% among Mexican American adolescents, with the striking finding that one in every two adolescents with obesity met criteria for MetS. This pattern is reinforced by Aneej et al. (2021), who found the prevalence of MetS to be 30% among overweight adolescents and 8.33% among obese adolescents, figures far higher than those typically reported in general adolescent samples.

Two studies converged on the finding that MetS prevalence is higher in urban than in rural adolescents. Sengottaian et al. (2025) and Sowmya et al. (2022) both reported a near two-fold difference, with urban prevalence at 7.9% compared to 4.2% in rural areas. The two independent studies strengthen the inference that residence-related differences in lifestyle exposure such as reduced outdoor physical activity, greater screen time, and easier access to processed and carbonated beverages are meaningfully associated with adolescent metabolic risk.

The reviewed literature reported a higher prevalence of MetS among male adolescents compared to female adolescents. Diego Ortega et al. (2025) and Sowmya

**et al. (2022)** both reported this trend, with prevalence of 5.7% in males compared to 4.7% in females. However, this sex-based pattern should be interpreted alongside the finding from **Aneej et al. (2021)** that obesity, overweight status, high fasting plasma glucose, and high waist circumference were the most common risk factors specifically among female adolescents.

Beyond overall prevalence, the reviewed studies provided useful detail on the distribution of individual MetS components. **Sowmya et al. (2022)** reported that among Indian adolescents, 11.9% had central obesity, 15.4% had elevated blood pressure, 26% had hypertriglyceridemia, 31.9% had low HDL cholesterol, and 3.7% had high fasting glucose. This distribution indicates that dyslipidaemia particularly low HDL cholesterol and elevated triglycerides was the most prevalent abnormality in this population, considerably more common than elevated fasting glucose. This is further supported by **Pei-Wen et al. (2022)**, who found that abdominal obesity (15%) and elevated triglyceride levels (5.7%) were independently associated with a greater risk of persistent MetS abnormality over time.

**Pei-Wen et al. (2022)** offered a rare longitudinal perspective within this review, following adolescents over 2.2 years to examine the incidence, risk, and remission of MetS. The study found that increased systolic blood pressure was associated with a higher incidence of new-onset MetS, while decreasing systolic blood pressure and glucose levels over time were associated with remission.

**Sengottaian et al. (2025)** contributed valuable diagnostic evidence by identifying an optimum waist-to-hip ratio cut-off of 0.56 (95% sensitivity, 84% specificity) and a triglyceride cut-off of 4.51 (92% sensitivity, 88% specificity) for identifying MetS in adolescents. These figures suggest that both anthropometric and biochemical markers can be used with reasonably high accuracy to flag adolescents at risk, offering a practical, low-cost, and non-invasive first-line screening option (waist-to-hip ratio) that could be paired with targeted biochemical testing (triglycerides) rather than requiring a full metabolic panel for every adolescent.

**Sengottaian et al. (2025)** and **Sreeja et al. (2024)** both identified decreased outdoor physical activity, more than two hours of daily screen time, and a preference for soft drinks or carbonated beverages as significant risk factors for MetS. **Sreeja et al. (2024)** additionally identified skipping meals, sleeping fewer than eight hours per night, and eating while using a screen as further contributing behaviours. These findings collectively describe a lifestyle pattern characterised by sedentary behaviour, poor dietary quality, and

disrupted sleep and meal routines — a cluster of modifiable behaviours rather than isolated risk factors. When considered together, the six studies in this review paint a coherent picture of adolescent MetS as a condition strongly linked to excess body weight, shaped by sex- and residence-based variation, driven predominantly by dyslipidaemia and central obesity rather than glucose dysregulation, and sustained or resolved by dynamic changes in blood pressure over time. Importantly, the behavioural risk factors identified screen time, physical inactivity, poor dietary choices, irregular meals, and inadequate sleep recur across multiple studies and settings, suggesting they are not incidental findings but a stable and generalisable risk profile.

### Nursing Implications

#### Nursing Practice

- Nurses play a pivotal role in the early detection of metabolic syndrome MetS among adolescents across school health, community, and outpatient settings. Since overweight and obese adolescents carry the highest MetS burden, nurses should routinely incorporate anthropometric assessments including waist circumference, waist-to-hip ratio (WHR), and BMI percentile into adolescent health encounters.
- Nurses should ensure systematic monitoring of key MetS components including blood pressure, fasting blood glucose, triglyceride levels, HDL cholesterol, and waist circumference at regular intervals, particularly among adolescents identified as at-risk.
- Nurses should recognize that adolescents with obesity, MetS, or chronic metabolic risk factors are at heightened risk for poor self-esteem, body image concerns, and depression. A holistic nursing approach that integrates mental health assessment alongside physical health screening is essential.
- Nurses are uniquely positioned as health educators to address the modifiable behavioral risk factors associated with adolescent MetS. Structured health education programmes should target on the risk behaviors of MetS
- Nurses should counsel adolescents and their families on the importance of regular outdoor physical activity and provide age-appropriate recommendations, emphasizing a minimum of 60 minutes of moderate-to-vigorous activity daily.

#### Nursing Education

- Metabolic syndrome which is an emerging and silent problems should be included in the nursing curriculum .
- Nurses working in the adolescent's clinic must be provided opportunity to attend the continuing nursing education program regarding early identification of metabolic syndrome.

#### **Nursing Research**

- Urban school nurses and community health nurses should implement population-based screening programs in high-risk urban schools and communities.
- Collaborative partnerships with local governments, schools, and community organizations can support the development of health-promoting environment.
- Nurses can facilitate family-based behavioral interventions that target shared risk factors, such as replacing screen time with family physical activities and promoting home-cooked meals over processed food consumption.
- Nursing research can be recommended on larger longitudinal cohorts across diverse populations,

#### **Nursing Administration**

##### **School health**

At the systems level, nurses should advocate for policies that support adolescent metabolic health, including mandatory physical education in schools, restriction of sugar-sweetened beverage marketing to adolescents, incorporation of MetS screening into national adolescent health programs, and training of school nurses in early MetS detection using validated anthropometric tools such as WHR and triglyceride thresholds. Nursing leaders and advanced practice nurses should contribute to the development of evidence-based clinical guidelines for adolescent MetS screening and management.

##### **Summary**

Nurses across all practice settings including clinical, school, community, and public health hold a critical role in the prevention, early detection, and management of metabolic syndrome in adolescents. By integrating evidence-based screening tools, delivering targeted lifestyle education, providing culturally sensitive care, ensuring longitudinal follow-up, and advocating for health-enabling policies, nurses can significantly reduce the burden of adolescent MetS and its long-term cardiovascular and metabolic consequences.

##### **Conclusion**

In summary, metabolic syndrome among adolescents is strongly associated with obesity, sedentary lifestyle,

and unhealthy dietary behaviors. Urbanization and gender differences further influence its distribution. Importantly, the condition is modifiable, as evidenced by remission associated with improvements in metabolic parameters. Therefore, comprehensive, multi-level interventions focusing on lifestyle modification and early screening are critical to prevent long-term cardiovascular and metabolic complications.

#### **Reference**

- Alowfi, A., et al. (2021). Prevalence and risk factors of metabolic syndrome among Saudi female adolescents in Jeddah. *International Journal of Environmental Research and Public Health*, 18(4), 2142. <https://doi.org/10.3390/ijerph18042142>
- Alvarez, M. V., Aparicio-Martinez, P., Pozo, F. J. F., Alonso, J. V., Sánchez, I. M. B., & Romero-Saldaña, M. (2020). A sustainable approach to the metabolic syndrome in children and its economic burden. *International Journal of Environmental Research and Public Health*, 17(6), 1891. <https://doi.org/10.3390/ijerph17061891>
- Aravindakshan, S. S., David, A., Saradakutty, G., et al. (2024). Prevalence of metabolic syndrome and its associated risk factors among schoolchildren aged 11–13 years living in Thiruvananthapuram District, Kerala, India: A nested case-control study. *Cureus*, 16(11), e72994. <https://doi.org/10.7759/cureus.72994>
- Bawaked, R. A., et al. (2022). Screen time increases overweight and obesity risk among adolescents: A systematic review and dose-response meta-analysis. *BMC Primary Care*, 23, 161. <https://doi.org/10.1186/s12875-022-01754-z>
- Centers for Disease Control and Prevention. (2022). *Childhood obesity facts*. <https://www.cdc.gov/obesity/data/childhood.html>
- Chung, Y. L., & Rhie, Y.-J. (2022). Metabolic syndrome in children and adolescents. *The Ewha Medical Journal*, 45(4), e13. <https://doi.org/10.12771/emj.2022.e13>
- de Ferranti, S. D., Gauvreau, K., Ludwig, D. S., Neufeld, E. J., Newburger, J. W., & Rifai, N. (2004). Prevalence of the metabolic syndrome in American adolescents: Findings from the Third National Health and Nutrition Examination Survey. *Circulation*, 110(16), 2494–2497. <https://doi.org/10.1161/01.CIR.0000145117.40114.C7>

- Fadzlina, A. A., et al. (2025). Metabolic syndrome in youth: A fresh look at an old problem. *Current Problems in Pediatric and Adolescent Health Care*. <https://doi.org/10.1016/j.cppeds.2025.101>.
- Noella NN, Niyonzima JB, Aboutaieb R. Study of the Determinants of Condom Use among Students at the University of Lake Tanganyika in Burundi : A Cross-sectional Analytical Study. *Oral Sphere J. Dent. Health Sci.* 2026;2(1):17-21. doi: 10.63150/osjdhs.2026.03
- Gutierrez-Marín, D., et al. (2025). Worldwide trends in metabolic syndrome from 2000 to 2023: A systematic review and modelling analysis. *Nature Communications*. <https://doi.org/10.1038/s41467-025>.
- Huang, J., et al. (2025). Sex differences in metabolic syndrome among U.S. adolescents, NHANES 1999–2020. *Diabetology & Metabolic Syndrome*. <https://doi.org/10.1186/s13098-025-xxxxxx>
- International Diabetes Federation. (2007). *The IDF consensus definition of metabolic syndrome in children and adolescents*. International Diabetes Federation.
- Jensen, M. L., et al. (2022). Television viewing and using screens while eating: Associations with dietary intake in children and adolescents. *Appetite*, 168, 105670. <https://doi.org/10.1016/j.appet.2021.105670>
- Liu, J., et al. (2022). Trends in metabolic syndrome among US youth from 1999 to 2018. *JAMA Pediatrics*, 176(10), 1043–1045. <https://doi.org/10.1001/jamapediatrics.2022.2544>
- Maffeis, C., et al. (2023). Waist-to-height ratio associated cardiometabolic risk phenotype in children with overweight/obesity. *BMC Public Health*, 23, 1547. <https://doi.org/10.1186/s12889-023-16430-z>
- Noubiap, J. J., et al. (2022). Global, regional, and country estimates of metabolic syndrome burden in children and adolescents in 2020: A systematic review and modelling analysis. *The Lancet Child & Adolescent Health*, 6(3), 158–170. [https://doi.org/10.1016/S2352-4642\(21\)00374-3](https://doi.org/10.1016/S2352-4642(21)00374-3)
- Okoli, A., et al. (2021). The relationship between sleep, obesity, and metabolic health in adolescents: A review. *Current Opinion in Endocrine and Metabolic Research*, 17, 15–19. <https://doi.org/10.1016/j.coemr.2020.11.002>
- Ortega-Pacheco, D., Rosales-Gomez, R. C., Garcia-Cobian, T. A., Rubio-Chavez, L. A., Gutierrez-Rubio, A. A., Rivera-Ramirez, J. H., & Gutierrez-Rubio, S. A. (2025). Metabolic syndrome prevalence and its components in adolescents from Western Mexico. *Pediatric Reports*, 17, 83. <https://doi.org/10.3390/pediatric17040083>
- Palanivel, S., et al. (2025). Predictors of metabolic syndrome and metabolic alterations among obese children and adolescents in South India. *[Journal Name]*, *[Volume]*(*Issue*), *[pages]*.
- Ramesh, et al. (2022). Prevalence of metabolic syndrome among adolescents in India: A population-based study. *BMC Endocrine Disorders*, 22, 258. <https://doi.org/10.1186/s12902-022-01163-8>
- Song, M., Kang, S., & Kang, H. (2024). The association between obesity measures and metabolic syndrome risk in Korean adolescents aged 10–18 years. *Journal of Multidisciplinary Healthcare*. <https://doi.org/10.2147/JMDH.S452600>
- Vargas-Hernández, A., et al. (2021). The hypertriglyceridaemic-waist phenotype as a valuable and integrative mirror of metabolic syndrome traits. *Scientific Reports*, 11, 21880. <https://doi.org/10.1038/s41598-021-01445-4>
- Vasquez, F., et al. (2019). A waist-to-height ratio of 0.54 is a good predictor of metabolic syndrome in 16-year-old male and female adolescents. *Pediatric Research*, 85, 269–274. <https://doi.org/10.1038/s41390-018-0195-7>
- Widjaja, N. A., Arifani, R., & Irawan, R. (2023). Cut-off value of waist-to-hip ratio as a predictor of metabolic syndrome in adolescents with obesity. *Acta Biomedica*, 94(3), e2023076. <https://doi.org/10.23750/abm.v94i3.14244>
- World Health Organization. (2020). *Obesity and overweight*. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
- World Health Organization. (2021). *Obesity and overweight*. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
- Wu, P.-W., Lai, Y.-W., Chin, Y.-T., Tsai, S., Yang, T.-M., Lin, W.-T., Lee, C.-Y., Tsai, W.-C., Huang, H.-L., & Seal, D. W., et al. (2022). Stability and transformation of metabolic syndrome in adolescents: A prospective

assessment in relation to the change of cardiometabolic risk factors. *Nutrients*, 14(4), 744. <https://doi.org/10.3390/nu14040744>

- Zhang, B., Shi, H., Cai, W., Yang, B., & Xiu, W. (2025). Metabolic syndrome in children and adolescents: Definitions, epidemiology, pathophysiology, interventions, and challenges. *Frontiers in Endocrinology*, 16, 1512642. <https://doi.org/10.3389/fendo.2025.1512642>
- Zhang, J., et al. (2026). The association of screen time with childhood obesity and metabolic status: A mediation analysis of cardiorespiratory fitness. *Frontiers in Endocrinology*. <https://doi.org/10.3389/fendo>.