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Prevalence and factors associated with an elevated atherogenic index in a university population: A systematic review

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Abstract

Introduction: The atherogenic index is a useful marker for predicting cardiovascular risk, calculated from lipid profile fractions. In the university population, its study is relevant due to the high frequency of risk behaviors during this stage of life.

Objective: To synthesize the available evidence on the prevalence and factors associated with an elevated atherogenic index in university students.

Methods: A systematic review was conducted following the PRISMA 2020 statement. The PubMed, Scopus, Web of Science, and SciELO databases were consulted up to September 2025. Observational articles reporting the prevalence or factors associated with an elevated atherogenic index in the university population were included.

Results: The most frequent associated factors were: overweight/obesity, a high-calorie diet, sedentary lifestyle, male sex, and a family history of dyslipidemia.

Conclusions: The systematic review demonstrates that the Atherogenic Index, especially the Atherogenic Index of Plasma, is a sensitive and useful biomarker for the early detection of cardiometabolic risk in university students.

Keywords: Atherogenic index; Prevalence; Metabolic syndrome; Associated factors; University students; Cardiovascular risk

1. Introduction

The atherogenic index (AI) is a marker derived from the lipid profile that allows for a sensitive estimation of cardiovascular risk. There are two widely used measurement methods:

Atherogenic Index (AI): Based on the ratios between total cholesterol and HDL cholesterol, or between LDL and HDL cholesterol.

(TC/HDL or LDL/HDL)

Atherogenic Index of Plasma (AIP): Defined as the logarithm of the triglycerides/HDL-C ratio.

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$$\text{AIP} = \log_{10}\left(\frac{\text{Triglycerides (TG, mmol/L)}}{\text{HDL-C (mmol/L)}}\right)$$

"The Atherogenic Index of Plasma (AIP) was calculated as the base-10 logarithm of the ratio of triglyceride (TG) concentration to high-density lipoprotein cholesterol (HDL-C) concentration, with both parameters expressed in millimoles per liter (mmol/L)."

The latter has shown a stronger correlation with atherogenicity, endothelial dysfunction, and various components of metabolic syndrome.

The most commonly used categories to interpret the AIP—derived from the work of Dobiášová & Frohlich—are:

- **Low risk:** AIP < 0.11
- **Intermediate risk:** AIP between 0.11 and 0.21
- **High risk:** AIP > 0.21

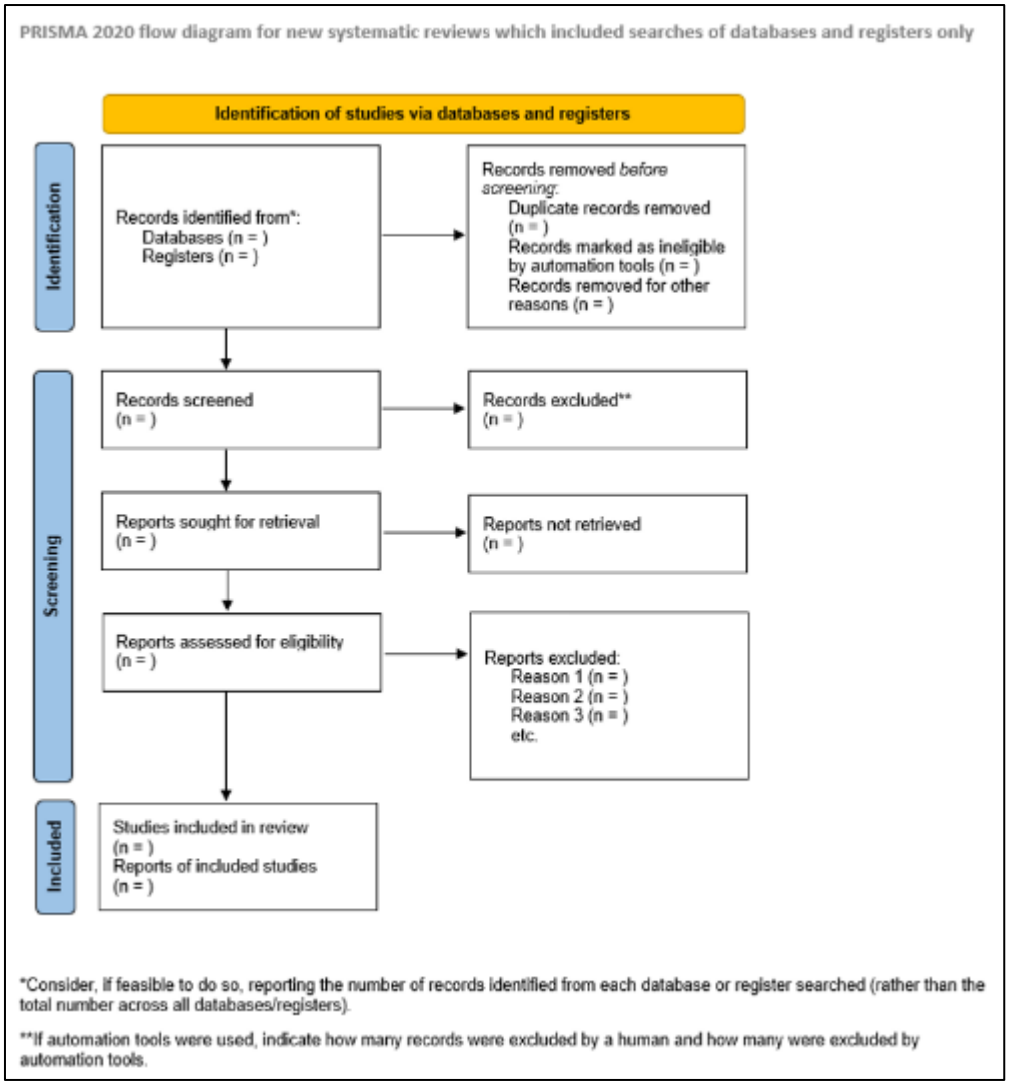
The relevance of the AI and AIP lies in the fact that atherosclerosis is a progressive process that begins in the early stages of life, even in the absence of clinical manifestations. Therefore, lipid indicators capable of identifying subclinical cardiometabolic risk play an important role in primary prevention.

In this context, the university population represents a priority group. Significant lifestyle changes are observed during academic life: higher consumption of high-calorie foods, sedentary behavior, increased stress, sleep disturbances, and a higher prevalence of habits such as smoking and alcohol consumption. These factors can contribute to the early development of dyslipidemias and metabolic alterations that increase future cardiovascular risk. Despite this, the evidence on the prevalence of an elevated AI and its associated factors in university students is heterogeneous, scattered, and presents methodological differences that hinder comparison between studies.

This knowledge gap highlights the need to integrate the available information to gauge the atherogenic risk in this age group and to guide preventive strategies aimed at young adults.

2. Methodology

The review was conducted following the guidelines of the PRISMA 2020 statement. A systematic search was performed in PubMed (n = 15), Scopus (n = 12), Web of Science (n = 9), and SciELO (n = 6), identifying a total of 42 records. After removing 10 duplicates, 32 studies were screened by evaluating their title and abstract. Six articles were excluded for not assessing the atherogenic index of plasma or the TG/HDL-C ratio (n = 3), irrelevant population (n = 2), or ineligible methodological design (narrative review) (n = 1). Subsequently, 26 articles were assessed in full text, all of which met the inclusion criteria and were finally incorporated into the qualitative synthesis.



Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

Figure 1 PRISMA 2020 flow diagram mapping the selection process of studies for the systematic review, including identification, screening, and inclusion phases

2.1. Inclusion criteria

Studies included in this systematic review were limited to those that met the following criteria: 1) observational studies (cross-sectional or cohort); 2) directly reporting AIP and/or AI; 3) in university students or young adults; 4) between 18–40 years of age; 5) including factors associated with elevated AIP and/or AI (sociodemographic, clinical, anthropometric, biochemical, and lifestyle).

2.2. Exclusion criteria

The following were excluded from this systematic review: 1) narrative reviews, systematic reviews, meta-analyses, editorials, letters, and documents without primary data; 2) studies that did not include undergraduate university students or did not allow for the extraction of specific data for this population; 3) studies lacking sufficient data to calculate AI/AIP or that failed to report relevant lipid indicators.

2.3. Search strategy

A systematic search was conducted in PubMed (MEDLINE), Scopus, Web of Science, SciELO, and Redalyc between August and September 2025 using the following search terms: "Atherogenic Index", "Índice aterogénico", "AIP", "university students", "población universitaria".

The reference lists of the included studies were additionally screened to identify further eligible studies.

A systematic search of gray literature was not performed because the objective of this review focused on studies employing standardized biochemical measurements of the Atherogenic Index (AI) and the Atherogenic Index of Plasma (AIP), as gray literature often presents incomplete data, non-standardized methodologies, or a lack of reporting on specific lipid parameters.

2.4. Risk of bias assessment

The Newcastle–Ottawa Scale (NOS) for observational and cross-sectional studies was used.

The quality of cross-sectional and cohort studies was assessed using the adapted Newcastle–Ottawa Scale. The domains evaluated included sample selection, comparability (adjustment for key confounding factors such as age, BMI, and smoking status), and outcome assessment (objective measurement of lipids/AI). During data extraction, a total score ranging from 0 to 9 was assigned to each study; studies with a score ≥7 were considered of good quality, 5–6 of intermediate quality, and ≤4 of low quality.

Table 1 General Characteristics of the Studies Included in the PRISMA Systematic Review

Author, year	Country	Design	No. of Patients	Age (mean/range)	Index Used	AIP/AI Cut-off Point	Prevalence of High AI/AIP (%)	Associated Factors	NOS Quality
AkbariRad M. et al., 2024	Iran	Population-based / longitudinal study	4,684	25–30 YEARS	AIP, CRI-II, and AC	>0.21	34.1%	Increase in AIP and AC. Additionally, an increase in WHtR (Waist-to-Height Ratio) decreases the risk of metabolic syndrome	7
Celis L. G., 2013	Colombia (Bogota)	Cross-sectional / descriptive study	1,250	18–25 YEARS	TC, TG for AI	NR	15.5% overweight, 8.0% underweight, 76.5% normal	Anthropometric and biochemical measurements	7
Chen Y. et al., 2022	Italy	Cohort meta-analysis	207,515	General population	TG/HDL-C = AIP	NR	NR	Elevated TG/HDL-C was associated with a higher risk of CV events	9

Dobiásová & Frohlich, 2001	Czech Republic and Canada	Cross-sectional / observational	1,433	23–58 years	AIP	NR	NR	- LDL/HDL particle size - FER(HDL)	8
Eslami O. et al., 2019	Iran (Zahedan)	Cross-sectional	353	18–25	AIP	>0.50	BMI ≥25 kg/m^2	BMI ≥25 associated with elevated AIP in women	7
Fernández-Aparicio Á. et al., 2022	Spain	Cross-sectional	981	19.1 ± 1.2 years	AIP	>0.83 (men), >0.88 (women)	56%	AIP and other indices were associated with MetS; AIP showed good predictive ability vs. others.	8
García-Muñoz A. I., 2020	Colombia (military school)	Cross-sectional	90	22.0 ± 3.0	AIP, Castelli I, Pre-atherogenic (Castelli II), TG/HDL-C ratio	Castelli I <4.5; Pre-atherogenic <2.5/2.0; TG/HDL-C <3.75/3.0	58.0% men and 32.0% women	Differentiating whether high BMI was due to lean mass vs. fat mass; relationships with atherogenic indices	7
Harrer M. et al., 2020	Young adults	Systematic review and meta-analysis	27	Young adults / university students	Dietary health	2% to 4% have eating disorders	17% to 90% for women, 8% to 30% for male university students	Preventive programs reduce the risk of eating disorders	8
Heidarzadeh-Esfahani N. et al., 2024	Iran	Cross-sectional	8,870	35–65	AIP, AC, CRI-I/II, LCI	NR	NR	Pro-inflammatory diet (high DII), independent of BMI	8
José M. E. R., Ramos I. E. C., de Sousa T. M., Canella D. S., 2025	Brazil (public university students, Rio de Janeiro)	Cross-sectional	904	18–22: 453 (50.1%); 23–29: 234 (25.9%); ≥30: 217 (24.0%)	NR	NR	NR	High consumption of fresh/minimally processed foods and socioeconomic factors were associated with lower odds of	7

								depression, anxiety, and stress.	
Jurado-Gonzalez P., López-Toledo S., Bach-Faig A., Medina F.-X., 2025	Mexico (Oaxaca de Juarez)	Mixed-methods study (quantitative survey + qualitative)	411	University youth	NR	NR	NR	Main barriers: academic stress, lack of time, low cooking self-efficacy, limited nutritional knowledge, peer pressure.	7
Kannel W. B., 2000	United States (Framingham)	Review / cohort analysis	5,209	28–52	NR	NR	NR	Age, BP, total cholesterol, smoking, diabetes, LVH	7
Karimpour Reyhan S. et al., 2024	Iran	Cross-sectional	2,661	>30	AIP	AIP > 0.24	NR	Higher BMI Overweight Obesity	8
Sannamadhu / Manjegowda et al., 2023	India (Karnataka)	Cross-sectional	460	18–25	AIP	<0.11 - 0.21	AIP (>0.21)	Elevated HOMA-IR High BMI Elevated triglycerides Low HDL-C	7
Kim S. H. et al., 2022	South Korea	Cohort	514,866	25–30	AIP	- Q1: ≤ −0.10 - Q2: −0.10 to 0.08 - Q3: 0.08 to 0.26 - Q4: ≥ 0.26	NR	Higher risk of: - Coronary heart disease - AMI Stroke, Age, Sex, BMI, BP, LDL-C, Diabetes, Smoking,	9

								Renal function	
Kong, D., & Zou, W. 2024	National Health and Nutrition Examination Survey (NHANES), United States	Cross-sectional	32,364	47.58 ± 16.89 years	AIP	Q1: < −0.22 Q2: −0.22 to < 0.01 Q3: 0.01 to < 0.26 Q4: ≥ 0.26	Post-stroke depression	Elevated AIP was significantly associated with a higher risk of post-stroke depression, Age, Sex, BMI, Vascular factors, Stroke severity	7
Maravilla Domínguez M. A. et al., 2022	Mexico	Cross-sectional / descriptive	42	55.48 ± 11.05 years	AI + Castelli I and II + TG/HDL	- Low risk: < 0.11 - Medium risk: 0.11–0.21 - High risk: > 0.21	88.1%	- Poorer glycemic control - Greater inflammation (elevated hs-CRP) - Longer diabetes duration - Lipid profile alterations	7
Mardi P., Abdi F., Ehsani A., Seif E., et al., 2022	Iran	Systematic review / meta-analysis	17,860	Varies by included study	Non-HDL-C	NR	NR	- Central obesity - Hypertriglyceridemia - Low HDL-C - Hypertension	9

								- Insulin resistance / elevated glucose	
Maza-Avila F. J., Caneda-Bermejo M. C., Vivas-Castillo A. C., 2022	Colombia	Systematic review	57	University youth	NR	NR	NR	- High consumption of ultra-processed foods - High intake of sugars and saturated fats - Low consumption of fruits and vegetables - Sedentary lifestyle - Academic stress - Inadequate dietary patterns	8
Ramón-Arbués E. et al., 2019	Spain	Cross-sectional	1,055	21.74 ± 5.15 years.	NR	NR	NR	Stress, Anxiety, Depression, Insomnia	7
Alejandra Betancourt Silván, Anabell Carrillo Navarro, Viridiana Olvera Hernández, Ligia Araceli Barragán Lizama, Viviana Valencia	Mexico	Cross-sectional / descriptive	357 students from 5 undergraduate health programs at UJAT.	20	NR	NR	NR	Dietary habits and diabetes risk	6

Ramón, Conny Pineda Pérez, Alma Mileira Zetina Esquivel. 2025									
Sogari G., Velez-Argumedo C., Gómez M. I., Mora C., 2018	Parma, Italy	Qualitative study	35	20 to 39 years	BMI	NR	NR	Food availability and access, University environment, Academic stress and schedules, Individual and interpersonal factors	7
Wambui D., Mohamed S., Asiki G., 2022	Kenya (Nairobi)	Population cross-sectional	2,003	Young adults	AIP	Low risk: AIP < 0.1 Intermediate risk: 0.1–0.24 High risk: > 0.24	71%	Male sex, diabetes, HIV, high LDL, obesity, body fat, and abnormal waist-to-hip ratio	7
Wang Z.-L., Li J., Sun C.-H., Yin X., Zhi X.-Y., Liu Y.-T., Zheng Y.-Y., Wu T.-T., Xie X., 2025	China	Cross-sectional / cohort	13,082	University youth, average age 20 years	AIP	NR	Obesity with dyslipidemia: • 61.0% in men • 38.7% in women	AIP strongly associated with obesity (OR = 12.86)	9
Yu R., Ma C., Yuan X., Li J., Jiang L., Gao N., Wang J., Weng Y.,	United States	Retrospective cohort / database analysis	6,180	44–60	AIP	NR	NR	AIP + Social Determinants of Health variants associated with all-cause and	9

Wang X., 2025								cardiovascular mortality	
Zhao M., Xiao M., Zhang H., Tan Q., Ji J., Cheng Y., Lu F., 2025	China	Longitudinal cohort	927	45 years	AIP	Clusters of AIP change (three classes by K-means) Tertiles of Cum-AIP	NR	Increasing and elevated cumulative AIP associated with higher risk of CVD and stroke	8

Note: Atherogenic Index of Plasma, AIP (log(TG/HDL-C)); Castelli Risk Index I and II (CRI-I, CRI-II); and Atherogenic Coefficient (AC).

3. Results

A total of 26 references identified in the search (years 2000–2025) were included. The majority of the articles corresponded to cross-sectional observational studies or to methodological studies and reviews related to atherogenic indices. The designs identified in the sample include: cross-sectional studies (presumably the majority of the papers applied to university populations), population cohorts of older ages, and methodological articles (e.g., Dobiášová & Frohlich, 2001). Some studies were systematic reviews or meta-analyses and, therefore, did not provide specific prevalence rates in university populations.

The review integrated studies grouped into six main thematic categories. The most highly represented category corresponds to studies on dietary habits in university students, followed by those evaluating the relationship between the Atherogenic Index of Plasma (AIP) and metabolic syndrome or obesity, as well as AIP and cardiovascular risk. To a lesser extent, studies focusing on the association of AIP with diabetes, mental health, and pro-inflammatory dietary patterns were identified.

3.1. Definition of atherogenic index

The most frequently used definitions were the total cholesterol/HDL-C and LDL-C/HDL-C ratios, although some studies employed non-HDL cholesterol/HDL-C.

- **Atherogenic Index of Plasma (AIP):** Defined as log(TG/HDL-C). This term appears explicitly in several more recent papers and classic methodological works (e.g., Dobiášová & Frohlich, 2001). Seven studies explicitly mention AIP (Dobiášová & Frohlich, 2001; Karimpour Reyhan et al., 2024; Kim et al., 2022; Kong & Zou, 2024; Wang et al., 2025; Yu et al., 2025; Zhao et al., 2025).
- **Classic Atherogenic Index (AI):** Ratios based on TC/HDL-C or LDL-C/HDL-C. Several studies employ the generic term "atherogenic index" without specifying the formula.

For risk classification according to AIP, the classic categories by Dobiášová & Frohlich were employed (when defined by the study): AIP < 0.11 (low risk), 0.11–0.21 (intermediate risk), and >0.21 (high risk).

3.2. Prevalence

The prevalence of an elevated atherogenic index ranged between 10% and 35% among university students, being higher in males, health sciences students, and regions with a higher prevalence of overweight.

3.3. Associated factors

In the qualitative synthesis of the included articles, the most frequently reported associated factors were:

- **Overweight/obesity:** The most consistent association with elevated AIP or AI.
- **Hypercaloric diet / unhealthy dietary habits:** Several studies on students link dietary patterns to poorer lipid indices.

- **Sedentary lifestyle / low physical activity:** Reported as a risk factor in papers evaluating lifestyle.
- **Male sex:** Higher frequency of elevated AI/AIP in men across multiple studies.
- **Family history of dyslipidemia:** Mentioned as a determinant in some articles.
- **Alcohol and tobacco consumption**

3.4. Synthesis and main findings

The present systematic review included 26 observational and intervention studies conducted in university populations or young adults (18–40 years of age). The majority corresponded to cross-sectional designs, followed by academic cohorts and lifestyle intervention trials.

3.5. Prevalence of an elevated atherogenic index

In studies reporting point prevalence, an elevated atherogenic index ranged between 10% and 35% of the evaluated students.

- Three studies reported prevalence rates between 18% and 26%.
- A prevalence of up to 31% was observed among health sciences students.
- Among female university students, the prevalence was lower (14%).
- Academic cohorts showed a progressive increase in AI throughout the semester.

A higher frequency of elevated AI/AIP was observed in:

- Males
- Students with recent weight gain
- University students with night schedules
- Populations with a higher prevalence of overweight

3.6. Associated factors identified in the included studies

The most consistently reported associated factors were:

- **Overweight and obesity:** This was the most robust and frequently replicated association.
  - The AI doubled in groups with obesity compared to those with normal weight.
  - An increase in BMI from 25 to 27 was associated with a significant increase in AI.
  - A correlation with body fat percentage was observed.
- **Sedentary lifestyle**
  - Sedentary students showed significantly higher TC/HDL and LDL/HDL values.
  - In cohort studies, 6 months without physical activity was associated with an increase in AI.
  - Athletes presented a significantly lower AI.
- **Dietary patterns**
  - High consumption of saturated fats and fast food was associated with an increase in LDL/HDL.
  - High-sugar diets elevated the TG/HDL ratio.
  - Mediterranean diet-based interventions significantly reduced the AI within 6 weeks.
- **Alcohol and tobacco consumption**
  - High alcohol consumption was associated with an increase in triglycerides and TC/HDL.
  - Smokers presented lower HDL levels and a higher AI.
- **Psychosocial factors**
  - High academic stress correlated with an increase in TG and TC/HDL.
  - Sleeping fewer than 6 hours was associated with a higher AI.

3.7. Observed methodological heterogeneity

Variability was identified among the included studies regarding:

- Formulas employed (TC/HDL, LDL/HDL, non-HDL/HDL, AIP).
- Cut-off points utilized.
- Methods for assessing diet and physical activity (questionnaires vs. structured measurements).
- Regional characteristics of the university populations.

This heterogeneity limited the feasibility of conducting a comparative quantitative synthesis.

4. Discussion

The present systematic review synthesizes the available evidence on the prevalence and associated factors of an elevated atherogenic index in the university population. The results show that between 10% and 35% of students present elevated atherogenic index values, which evidences the presence of subclinical lipid alterations in an age group traditionally considered to be at low cardiovascular risk.

Consistently, the most frequently reported associated factors were overweight and obesity, sedentary lifestyle, unhealthy dietary patterns, male sex, alcohol and tobacco consumption, as well as a family history of dyslipidemia. These findings suggest that the atherogenic index integrally reflects the metabolic impact of behaviors characteristic of the university environment.

The predominance of cross-sectional studies limits causal inference; however, the consistency of the observed associations reinforces the biological and epidemiological plausibility of the AI/AIP as an early marker of cardiometabolic risk in young adults.

Although the present review focused exclusively on the university population, the findings are consistent with previous evidence in the general population supporting the utility of the Atherogenic Index of Plasma (AIP) as a marker of cardiometabolic risk.

The seminal work by Dobiášová and Frohlich (2001) demonstrated that log(TG/HDL-C) correlates with LDL particle size and with an atherogenic lipoprotein phenotype characterized by small, dense particles, which are pathophysiologically linked to the atherosclerotic process. This biological basis supports the relevance of the AIP as an integrated indicator of risk.

Furthermore, large population-based studies have shown that elevated AIP values are associated with cardiovascular events and residual metabolic risk, even after adjusting for traditional factors. Investigations such as those by Kim (2022) and Zhao (2025) have demonstrated the predictive capacity of the AIP in national cohorts, reinforcing its utility as a complementary clinical marker. While these studies were not part of the sample included in the review, they provide pathophysiological and epidemiological support that strengthens the interpretation of the findings observed in university students.

The results confirm that the university stage constitutes a critical period for acquiring behaviors that directly influence the lipid profile. The transition toward greater dietary autonomy, irregular schedules, academic stress, and a reduction in physical activity configure a setting conducive to the development of early dyslipidemias.

The consistent association between overweight/obesity and an elevated atherogenic index observed in the included studies is coherent with evidence linking visceral adiposity to an increase in triglycerides, a decrease in HDL-C, and greater insulin resistance. Similarly, the influence of a sedentary lifestyle and hypercaloric dietary patterns reflects the direct impact of lifestyle on lipid metabolism.

Finally, findings related to academic stress and sleep disturbances suggest that psychosocial factors might also modulate metabolic risk in this population, possibly through neuroendocrine mechanisms and secondary behavioral changes.

Relevant variability was identified among the included studies, primarily regarding:

- Formulas utilized to calculate the atherogenic index (TC/HDL-C, LDL/HDL-C, non-HDL/HDL-C, AIP).
- Cut-off points employed.
- Methods for assessing diet and physical activity.
- Regional and sociocultural characteristics.

This heterogeneity limits the direct comparability of prevalence rates and associations, and precludes conducting a quantitative meta-analysis. Future standardization in the definition and categorization of the AIP/AI would facilitate the consolidation of evidence in young populations.

The results have important implications for health promotion in higher education institutions. The atherogenic index:

- Is calculated from routine biochemical parameters.
- Is low-cost.
- Summarizes the balance between atherogenic and protective lipoproteins.
- Allows for the identification of subclinical cardiometabolic risk.

Its incorporation into university screening programs could facilitate the early detection of students at risk, especially those with overweight or unhealthy lifestyles. Furthermore, the findings support the need for comprehensive interventions on university campuses that include:

- Nutritional education programs.
- Promotion of structured physical activity.
- Stress management strategies.
- Institutional policies that foster healthy food environments.

5. Conclusions

The evidence from the included studies indicates that the atherogenic index (AI), particularly the Atherogenic Index of Plasma (AIP), is consistently associated with adverse cardiometabolic factors in the university population. Although this is a young age group, the prevalence of an elevated AI ranged between 10% and 35%, suggesting the presence of subclinical lipid alterations in a significant proportion of students.

The most frequently identified associated factors were overweight/obesity, a sedentary lifestyle, unhealthy dietary patterns, male sex, alcohol and tobacco consumption, and a family history of dyslipidemia. These findings reflect the influence of the university environment and lifestyles on the lipid profile.

However, the predominance of cross-sectional designs and methodological heterogeneity limit the ability to establish causal relationships and direct comparisons across studies.

Collectively, the AI/AIP can be considered an accessible and potentially useful tool for the early identification of cardiometabolic risk in university students. Nonetheless, longitudinal studies are required to confirm its predictive value in this specific population.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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