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Narrative review: Ultra-processed foods and the risk of metabolic syndrome

Narrative review: Ultra processed food dan risiko terjadinya sindrom metabolik

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Abstract

Ultra-processed foods generally contain high levels of energy, sugar, sodium, and saturated fat, and low levels of fiber and micronutrients. Excessive consumption of ultra-processed foods can potentially trigger metabolic dysfunction via inflammatory pathways, insulin resistance, and lipid homeostasis disorders. This study aimed to review the scientific evidence regarding the relationship between ultra-processed food consumption and the risk of metabolic syndrome. This narrative literature review was conducted using a systematic search of the PubMed and ScienceDirect databases (2020–2025). The inclusion criteria were observational studies on related topics, articles in English, and full texts, while the exclusion criteria were studies on animals/cell cultures and non-full-text articles. The results of this study showed a consistent relationship between UPF consumption and an increased risk of metabolic syndrome. Individuals in the highest quartile of UPF consumption were 3.27 times more likely to develop metabolic syndrome (OR=3.27; 95% CI: 2.76–3.89; p<0.001). Additionally, high UPF consumption was associated with increased weight, BMI, waist circumference, blood pressure, fasting blood glucose, HbA1c levels, and triglyceride levels. In conclusion, high UPF consumption consistently increases the risk of metabolic syndrome; therefore, limiting UPF and improving the diet may be a preventive strategy.

Keywords: Metabolic syndrome, NOVA classification, ultra-processed food.

Abstrak

Ultra Processed Food (UPF) umumnya mengandung tinggi energi, gula, natrium, lemak jenuh, dan rendah serat serta mikronutrien. Konsumsi UPF secara berlebihan, dapat berpotensi memicu disfungsi metabolik melalui jalur inflamasi, resistensi insulin, dan gangguan homeostasis lipid. Studi ini bertujuan untuk meninjau kembali bukti ilmiah mengenai hubungan konsumsi UPF dan risiko sindrom metabolik. Kajian dilakukan menggunakan *narrative literature review* dengan pencarian sistematis pada basis data *PubMed* dan *ScienceDirect* (2020–2025). Kriteria inklusi meliputi studi observasional mengenai topik terkait, artikel berbahasa inggris, dan *full text*. Kriteria eksklusi meliputi penelitian pada hewan/sel kultur, dan *non full text*. Hasil kajian menunjukkan hubungan yang konsisten antara konsumsi UPF dan peningkatan risiko sindrom metabolik. Individu pada kuartil tertinggi konsumsi UPF memiliki kemungkinan 3,27 kali lebih besar mengalami sindrom metabolik (OR=3,27;95%, CI:2,76–3,89; p<0,001). Selain itu, konsumsi UPF tinggi dikaitkan dengan peningkatan berat badan, BMI, lingkar pinggang, tekanan darah, glukosa darah puasa, HbA1c, dan trigliserida. Kesimpulannya, konsumsi UPF yang tinggi secara konsisten meningkatkan risiko sindrom metabolik, sehingga pembatasan UPF dan perbaikan pola makan dapat menjadi strategi pencegahan

Kata Kunci: *NOVA classification*, sindrom metabolik, *ultra processed food*

Introduction

In recent decades, global food consumption patterns have significantly transformed. The consumption of Ultra-Processed Foods (UPF) continues to rise, particularly in middle-income countries. In the United States, the average percentage of calories derived from UPF in the population aged ≥1 year was approximately 55% between August 2021 and August 2023 (Williams & Ogburn, 2025). In Europe, studies have shown that the energy contribution from UPF and ultra-processed beverages in 22 countries varies between approximately 14% and 44% (Mertens et al., 2022). In Indonesia, the average contribution of UPF to the total daily energy intake is approximately 19.5% among adolescents and young adults in urban areas. These results indicate that nearly one-fifth of the daily energy intake of the study sample comes from UPF, which is dominated by products such as packaged snacks, sweetened beverages, and instant products (Arumsari et al., 2025). Other studies have shown that approximately 25.7% of the total daily energy intake in Indonesia comes from UPF (Setyaningsih et al., 2024).

The food ecosystem in Indonesia is increasingly dominated by UPF products that are high in sugar, salt, and fat, and are easily accessible and affordable. This change reflects a shift in the eating patterns of modern societies from natural or minimally processed foods (e.g., vegetables, fruits, grains, and simple side dishes) to high-calorie, low-nutrient processed foods, which are often promoted in the global food system and local retail markets (Colozza & Avendaño, 2019; Nurhasan et al., 2024a). This dietary shift is accompanied by increasingly sedentary lifestyles, urbanization, and the increased availability of fast food and packaged foods. Consequently, although energy intake may be sufficient or even excessive, diet quality has declined, with low fiber levels, insufficient micronutrients, and increased consumption of added sugars, sodium, and saturated fats (Andriyani et al., 2024; Nurhasan et al., 2024b).

UPF products generally have characteristics such as high calori,es low fiber, and low micronutrient contents, and often contain additives such as emulsifiers, stabilizers, colorings, and artificial flavors (Monteiro et al., 201). Consequently, UPF consumption patterns have been identified as potential risk factors for various metabolic conditions. In contrast, metabolic syndrome is a cluster of risk factors that include central obesity (excess abdominal fat), hypertension, dyslipidemia (high triglycerides and low HDL), and glucose disorders (including insulin resistance) (Canhada et al., 2023). The prevalence of metabolic syndrome has increased worldwide. In Indonesia, one study reported a prevalence of metabolic syndrome of 21.66%, with variations between provinces and ethnic groups. Another study showed that in the 45-65 age group in Indonesia, the prevalence reached 39.0% (male) and 46.2% (female) (Herningtyas & Ng, 2019; Sigit et al., 2020). Early epidemiological studies have shown a positive association between UPF intake and obesity, excess waist circumference, and other metabolic risk factors. For example, a cohort study in the UK found that UPF consumption was associated with a 79% increase in the risk of obesity (Rauber et al., 2021).

Most available research and reviews tend to focus on single outcomes, such as obesity or increased body mass index, while metabolic syndrome as a cluster of risk factors reflecting systemic metabolic dysfunction is still relatively underdiscussed comprehensively. In addition, several previous systematic reviews have emphasized energy intake or obesity as a single outcome without discussing the potential mechanisms linking UPF to metabolic dysfunction. Furthermore, this review highlights the biological mechanisms underlying this relationship, providing a more comprehensive perspective. Based on this background, this article aims to review the latest scientific evidence on the relationship between UPF consumption and an increased risk of metabolic syndromes.

Methods

This study used a narrative literature review method to synthesize previous research findings discussing the relationship between UPF consumption and increased risk of metabolic syndrome. This method was chosen because it provides a comprehensive overview of various relevant scientific findings, including the underlying biological mechanisms and variations in the results between studies. The article search process was conducted through a systematic search of two indexed scientific

databases, PubMed and ScienceDirect. The literature search used a combination of keywords "ultra-processed food" AND "metabolic syndrome" OR "ultra processed food and metabolic syndrome" OR processed food consumption OR dyslipidemia and ultra-processed food OR insulin resistance and ultra-processed food.

The inclusion criteria in this review included articles that discussed the relationship between UPF consumption and the risk of metabolic syndrome or its components, namely central obesity/waist circumference, dyslipidemia (high triglycerides and/or low HDL), hypertension, hyperglycemia or insulin resistance, English-language articles, full text, published between 2020 and 2025, and the types of studies included were observational studies, including cross-sectional, case-control, and cohort studies. The exclusion criteria were studies on animals or cell cultures and articles that were not available in full text.

The article selection process was carried out by reviewing the eligibility of each article based on the title, abstract, manuscript content, research methods, study design, sample, and the main results reported. All relevant information was compiled in a matrix table to facilitate comparison and analysis between studies. Based on the selection results, four articles were deemed to meet the criteria and were eligible for further review in accordance with the research topics. The number of articles included was limited because of the application of strict inclusion criteria, including publication period restrictions and the requirement to use English-language articles. The restriction of using English-language articles was applied to maintain consistency in the terminology and methodological comparability. In addition, most scientific publications related to UPF and metabolic syndrome are available in English.

The analysis stage was performed in several steps. First, each selected article was summarized, including the author's name, year of publication, journal title, research methods used, main results, and database sources. These summaries were used as the basis for the data grouping. Second, the researchers formulated research questions related to the main topic to facilitate the determination of the focus and subheadings in the discussion section with reference to the summary of the selected articles. Third, an in-depth analysis was conducted through a discussion linking the research results to relevant theories, concepts, and findings. This article is a literature review and does not directly involve human subjects; therefore, it does not require ethical approval.

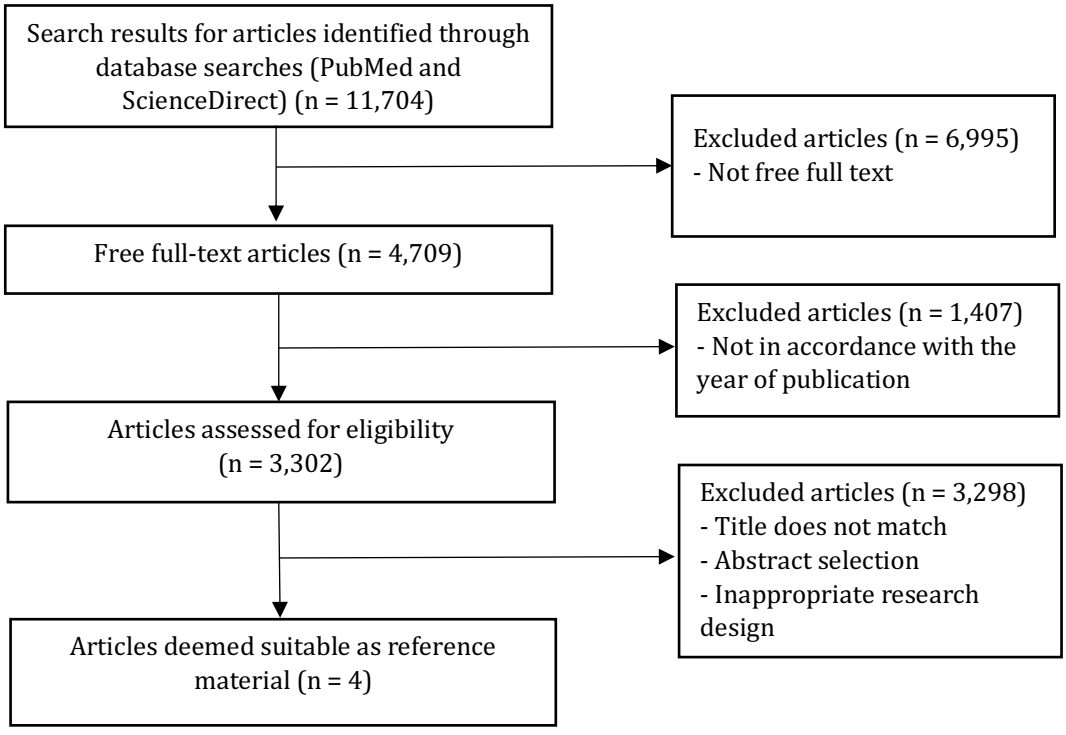

Figure 1. Article search flowchart

Result and Discussion

Table 1. Summary of articles that meet the research objectives criteria

Author and Year	Journal	Title	Method	Results
Scheine Leite Canhada (2023)	Diabetes Care	Ultra-Processed Food Consumption and Increased Risk of Metabolic Syndrome in Adults: The ELSA-Brasil	This was a Multicenter Prospective Cohort Study (Longitudinal Cohort Study). Of the 15,105 initial respondents, 2,508 had newly diagnosed metabolic syndrome. The median age of the respondents was 49 years with 58.7% being female. The control variables included sociodemographic factors, behavioral factors such as smoking, physical activity, and alcohol consumption, and total energy intake.	An increase in UPF consumption of 150 g/day was associated with a 7% increase in the risk of metabolic syndrome (RR = 1.07; 95% CI: 1.05–1.08) after energy adjustment and a 4% increase in risk after BMI adjustment (RR = 1.04; 95% CI: 1.02–1.06). Compared to the lowest consumption quartile (<234 g/day), the highest quartile (>552 g/day) had a 19–33% higher risk of metabolic syndrome. The relationship between UPF consumption and metabolic syndrome was linear and statistically significant.
Sanaz Mehrabani (2023)	Food Science and Nutrition	Consumption of ultra-processed foods could influence the odds of metabolic syndrome: A cross-sectional study	The methods used were cross-sectional and prospective cohort studies. Of the 11,907 individuals aged 35-70 years, 8,841 respondents were excluded and included in the final analysis. The average age of the respondents was 48.7 years, with 56.1% being female. The control variables were age, total energy intake, education level, physical activity, BMI, medication use, and exposure to cigarette smoke.	Compared with the first quartile (lowest), the highest quartile of UPF consumption had a 3.27 times higher risk of metabolic syndrome (OR = 3.27; 95% CI: 2.76–3.89; $p < 0.001$). A significant positive association was observed between UPF consumption and metabolic syndrome.
Sandra Gonzalez-Palacios et al (2023)	Elsivier	Increased ultra-processed food consumption is associated with worsening of cardiometabolic risk factors in adults with	This was a 12-month prospective multicenter randomized controlled trial (RCT). A total of 5,373 respondents participated in the study. The average age of the respondents was 65.1 years, with a male-to-female ratio of 51.8% to 48.2%. The control variables included age, sex, follow-up time, education level, smoking	Specifically, the group with the highest UPF consumption had a higher body weight by an average of 1.09 kg, an increase in BMI of 0.39 kg/m^2, and an increase in waist circumference of 1.03 cm, compared with the group with the lowest UPF consumption. In addition, an increase in diastolic blood pressure of 0.67 mmHg,

		metabolic syndrome Longitudinal analysis from a randomized trial of a	status, physical activity, sedentary time, and adherence to the Mediterranean diet.	fasting blood glucose of 1.66 mg/dL, and HbA1c levels of 0.04% were also observed. The lipid factors showed unfavorable changes, with triglyceride levels increasing by 6.79 mg/dL and the triglyceride-glucose index increasing by 0.06 in the group with the highest UPF consumption.
Lidia Bezerra Barbosa (2023)	International Journal for Equity in Health	Ultra-processed food consumption and metabolic syndrome: a cross-sectional study in Quilombola communities of Alagoas, Brazil	This was a cross-sectional study. The respondents in this study were women aged 19-59 years living in Brazil, totaling 896 respondents. The control variables used were sociodemographic factors, lifestyle and health factors, and anthropometric factors, such as BMI and neck circumference.	Of the 895 women studied, nearly half (48.3%) had metabolic syndrome, with an average of 15.9% of the daily energy intake coming from UPF. Higher UPF consumption was associated with a 30% increase in hypertension risk. Lower NOVA scores were protective against diabetes mellitus (PR = 1.30; 95% CI: 1.06–1.61) and low HDL levels (PR = 0.90; 95% CI: 0.81–0.99).

Overview of Ultra-Processed Foods

Over the past few years, there has been a rapid and significant increase in the availability and variety of UPF products marketed in countries with varying levels of economic development, particularly in low- and middle-income countries with large populations (Baker et al., 2020). UPF consumption has grown significantly, replacing healthy food patterns such as nuts, legumes, vegetables, and fruits (Leo & Campos, 2020). Based on the research results of Kinasih et al. (2024), the dietary patterns of Indonesians, especially in the city of Semarang, are still below expectations because they do not meet the dietary pattern score (AHEI) and nutritional guidelines. For example, red meat is more often consumed in processed forms, such as sausages, salted meat, and meatballs, which are classified as UPF.

UPF contain saturated and trans fats, salt, added sugars, high energy content, and low fiber, protein, and micronutrient content (Martinez-Perez et al., 2021). Based on research results from Machado et al. (2019), UPF products were found to contain 4.7, 2.9, and 1.9 times more free sugars and sodium, and 1.7 and 1.4 times less potassium and fiber than non-ultra-processed products. This nutrient composition is consistent with empirical findings from the reviewed studies, where high UPF consumption was associated with increased blood pressure and triglyceride levels and decreased HDL levels, which are indicators of metabolic syndrome.

The concept of UPF emerged within the framework of a food classification system, the NOVA classification system. Foods were classified into four groups: (1) whole or minimally processed foods/beverages, (2) minimally processed ingredients, (3) processed foods, and (4) ultra-processed foods (UPF). UPF is the fourth category of industrial products that undergo several stages of processing and contain additives such as emulsifiers, artificial sweeteners, preservatives, colorings, or ingredients that are not commonly used in the household. Their distinctive characteristics include a long shelf life, industrial packaging, highly appealing taste (hyper-palatable), and being ready-to-eat or ready-to-heat ( ).

The phenomenon related to UPF can be caused by several factors, such as urbanization, the influence of food marketing, lifestyle changes, and reduced time for preparing food from raw ingredients. Based on the results of research by (Sihombing & Ningsih, 2021),

people in Indonesia, especially in Batam City, prefer to spend time visiting fast food restaurants, especially office workers. This preference for convenient foods is closely related to the types of UPF products, such as packaged sweet drinks, packaged snacks such as candy, ice cream, chocolate, savory snacks, sweet instant cereals, ready-to-eat meals, and other instant mixes. UPF consumption accounts for a large portion of the daily energy intake in some populations, especially in developed and developing countries. In the context of Indonesia/Southeast Asia, although specific data on UPF consumption are still limited, the trend of increasing industrial processed foods and decreasing consumption of traditional foods is a phenomenon that should be monitored as part of the nutritional transition (Miranda et al., 2021).

UPF consumption often leads to an increase in daily energy intake and an unbalanced diet (Ganesrau et al., 2023). Additionally, there is a positive association between UPF consumption and the risk of all-cause mortality, such as coronary heart disease, cerebrovascular disease, metabolic syndrome, hypertension, overweight, depression, obesity, irritable bowel syndrome, and gestational obesity (Chen et al., 2020).

Overview of Metabolic Syndrome

Metabolic syndrome is a cluster of metabolic disorders, including central obesity, insulin resistance, high blood pressure, and dyslipidemia. This condition increases the risk of atherosclerotic cardiovascular disease and type II diabetes mellitus.

The diagnosis of metabolic syndrome requires the presence of three or more metabolic abnormalities. The underlying etiology of metabolic syndrome is multifactorial. The causes include genetic predisposition and various environmental or lifestyle factors, including obesity, lack of physical activity, and unhealthy eating habits (Xu et al., 2018). The core of this syndrome is the accumulation of fatty tissue, especially in the abdomen, which causes insulin resistance. Proinflammatory cytokines, such as tumor necrosis factor, leptin, adiponectin, plasminogen activator inhibitor, and resistin, are released from enlarged adipose tissue, which negatively alters and affects insulin (Fahed et al., 2022).

Consumption of Ultra-Processed Foods and the Risk of Metabolic Syndrome

Based on the results of a study from the, high consumption of ultra-processed foods (UPF) was independently associated with an increased risk of metabolic syndrome during an approximately eight-year follow-up period. The study observed a consistent and significant increase in waist circumference ($p = 0.003$), with an average difference of 0.7 cm between participants with high UPF consumption (700 g/day) and those in the reference consumption group (234 g/day). For triglycerides ($p = 0.26$), there was a stable upward trend of 2 mg/dL at higher UPF consumption levels, although this was not statistically significant. A similar trend was observed for HDL cholesterol ($p = 0.13$), where there was a decrease of 0.6 mg/dL in the intervention group. Meanwhile, both systolic blood pressure ($p = 0.002$) and diastolic blood pressure ($p = 0.003$) showed a statistically significant increase of 0.6 mmHg. No significant increase in risk was found for plasma glucose levels in relation to UPF consumption ($p = 0.62$). Thus, respondents with high UPF intake (>552 g/day) had a 19% greater risk of developing metabolic syndrome than those with low UPF intake (<234 g/day).

Based on other studies, namely research from Mehrabani et al. (2024), UPF intake is associated with components of metabolic syndrome, such as high blood pressure, fasting blood sugar, triglycerides, and low HDL-C. In a cohort study of middle-aged Spaniards, UPF consumption was associated with a high risk of hypertension (Mendonça et al., 2017). A systematic review and meta-analysis also revealed that high UPF consumption is associated with a high risk of hypertension in adults (Vitale et al., 2024). Many UPFs contain high amounts of sodium, which is a risk factor for hypertension (Fillipini et al., 2022). Additionally, in a cross-sectional study of school children in Brazil, UPF consumption was associated with increased fasting glucose (Rinaldi et al., 2016). Based on the results of a study by Campà et al. (2019), the total energy intake from free sugar intake increased from 9.9% to 15.4%, and that from dietary fiber intake decreased from 8.36% to 6.86%.

In other studies, a link between UPF intake and hypertriglyceridemia and decreased HDL-C levels has been reported (Donat-Vargas et al.,

2021). Excessive energy intake from UPF consumption leads to obesity, which is a known cause of cardiometabolic risk factors. UPF also contains saturated and trans fatty acids, which can increase the risk of dyslipidemia (Mambrini et al., 2023).

In one aspect of metabolic syndrome, namely glucose levels, as UPF consumption increases, fasting blood glucose and HbA1c levels also increase. This indicates that UPF consumption not only affects obesity and lipids but also contributes to glucose metabolism dysfunction, as reflected by an increased risk of metabolic syndrome. One study from the Llavero-Valero et al. (2021) found that compared to the group with the lowest UPF consumption, adults with the highest UPF consumption had a higher risk of developing type 2 diabetes mellitus. Additionally, UPF consumption is associated with plasma triglyceride levels, and there is a positive correlation between total cholesterol and a 5% increase in UPF consumption (González-Palacios et al., 2023). Findings from González-Palacios et al. (2023) indicate that compared to the lowest UPF consumption, the highest UPF consumption is prospectively associated with body weight, body mass index, waist circumference, fasting blood glucose, glycated hemoglobin, triglycerides, and the triglyceride-to-glucose ratio in adults with metabolic syndrome after 12 months of observation.

Based on the results of several studies, it can be said that the high content of added sugar, sodium, saturated fat (SFA), and trans fat (TFA) in UPF can play a direct or indirect role in triggering various metabolic disorders. In addition, hydrogenated packaging technology and the possibility of contamination with substances such as bisphenol and phthalates may also be associated with the occurrence of dyslipidemia through disturbances in triglyceride, HDL, and LDL levels.

More than half of the UPF products used refined sugar. Free sugars have a high glycemic index that can trigger weight gain due to increased appetite and desire to eat. Excessive sugar consumption also increases the risk of cardiometabolic disorders through increased oxidative stress, inflammation and endothelial dysfunction. In addition, excessive salt intake can increase the risk of hypertension, which is a major factor in heart disease and strokes. A high sodium intake has been shown to increase blood pressure by disrupting renal and extrarenal homeostasis, affecting neurohormonal pathways, and having a direct effect on blood vessels (Poursalehi et al., 2024). UPF also tends to be high in fat, particularly SFA and TFA, which enhance the flavor of products. However, TFA (especially from hydrogenated oils) and SFA have adverse effects on lipid profiles, including lowering HDL levels and increasing triglyceride levels (DiNicolantonio & O'Keefe, 2018).

The most consumed food subgroups from UPF were packaged snacks (chips) or salty crackers (26.0%), margarine (20.2%), sweet biscuits with or without filling (16.5%), powdered drink mixes (14.5%), and bread such as hot dog buns, hamburger buns, or similar (13.6%). Of the 895 women studied, nearly half (48.3%) had metabolic syndrome, with an average of 15.9% of the daily energy intake coming from UPF (Barbosa et al., 2023).

Confounding factors play an important role in all studies reviewed and directly influence the strength and consistency of the relationship between UPF consumption and the risk of metabolic syndrome. In general, the reviewed articles were adjusted for sociodemographic factors (age, sex, education, and socioeconomic status), behavioral factors (physical activity, smoking, alcohol consumption, and sedentary time), and dietary factors (total energy intake, diet quality, and adherence to a healthy diet).

Several studies have controlled for anthropometric indicators, particularly Body Mass Index (BMI), which showed that obesity acts as a partial mediator in the relationship between UPF consumption and metabolic syndrome. After adjusting for this factor, the strength of the relationship tended to decrease but remained significant, indicating that the effects of UPF are not solely attributable to excess weight.

Efforts to Overcome Metabolic Syndrome

All components of metabolic syndrome are related to lifestyle, and a healthy lifestyle is an effective way to manage metabolic syndrome risk factors and prevent cardiovascular complications. Recommended lifestyle modifications include physical activity, a healthy diet, avoiding tobacco use, maintaining adequate sleep, and reducing alcohol intake. The American Heart Association and American College of Cardiology recommend 150 min of moderate-

intensity physical activity or 70 min of vigorous-intensity physical activity for adults each week (Arnett et al., 2019).

A diet rich in vegetables, fruits, legumes, whole grains, nuts, and fish is recommended for reducing cardiovascular diseases. It is also recommended to avoid processed foods, refined carbohydrates, diets high in saturated fat, and to reduce sodium intake. Individual lifestyle modifications according to age and sex can help maintain a healthy lifestyle (Eckel et al., 2014). In addition to individual efforts, other efforts can be made, such as in China, Singapore, the United States, and several other countries. Each country has regulations and strategies to prevent degenerative diseases, such as diabetes mellitus, through the control of sweet and high-calorie food and beverage products, namely, by using nutrition information labels based on strata/levels that make it easier for consumers to know and choose healthy food and beverage products. In addition to the use of nutritional information labels, some countries have implemented consumption taxes on packaged foods and beverages.

A limitation of this review is that the number of articles included was relatively limited. This is due to the application of strict inclusion criteria, including restrictions on the publication period (2020–2025), study design type, and the requirement for full-text articles in English. This limitation in the number of articles may affect the completeness of the scientific evidence and limit the review's ability to capture the full range of research results. In addition, there was heterogeneity among the studies reviewed, both in terms of how UPF consumption was measured, the criteria for determining metabolic syndrome, and the characteristics of the respondents and study design.

Conclusion

Consistently high consumption of UPF can increase the risk of metabolic syndrome. Reducing UPF consumption has been shown to lower the risk of and help improve the components of metabolic syndrome.

Recommendations, it is necessary to develop public health policies that encourage restrictions on UPF, clearer food labeling, and nutrition education based on whole foods should be prioritized in order to reduce the increase in metabolic syndrome. There is a need to strengthen nutrition policies, such as more informative food labeling and control of the marketing of ultra-processed products, especially for younger age groups. In the context of public education, nutrition messages must be directed at increasing public literacy regarding the impact of UPF consumption on long-term metabolic health. Nutrition education that emphasizes the introduction of ultra-processed foods, understanding food labels, and the importance of consuming minimally processed foods can encourage healthier consumption behavior. The clinical implications of these findings are also significant; UPF consumption needs to be considered as part of the assessment of metabolic syndrome risk in healthcare practices. Dietary anamnesis, including the frequency and type of UPF consumption, can help healthcare professionals identify modifiable risk factors. Reducing UPF consumption can be recommended as an initial non-pharmacological strategy for the prevention and management of metabolic syndrome, along with other lifestyle interventions, such as increased physical activity.

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