

Ultra-processed food consumption and non-alcoholic fatty liver disease, metabolic syndrome and insulin resistance: a systematic review

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Supplementary data

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PRISMA 2020 Checklist

Table S1. PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Pages 1, 2
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 2
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 2
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Pages 2
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Suppl. Tables S2, S3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Page 2
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	N/A
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 2
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 2
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 2, 3
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Tables 1, 2

Section and Topic	Item #	Checklist item	Location where item is reported
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Page 2
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	N/A
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Page 3
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 3
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Suppl. Table S4
Study characteristics	17	Cite each included study and present its characteristics.	Tables 1, 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Suppl. Table S5
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Tables 1, 2
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Pages 3, 6
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A

Section and Topic	Item #	Checklist item	Location where item is reported
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Pages 12, 14
	23b	Discuss any limitations of the evidence included in the review.	Pages 12, 14
	23c	Discuss any limitations of the review processes used.	Page 14
	23d	Discuss implications of the results for practice, policy, and future research.	Page 15
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number / state that the review was not registered.	Page 2
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 2
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 16
Competing interests	26	Declare any competing interests of review authors.	Page 16
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Template data collection forms: N/A Data extracted from included studies: Tables 1, 2 Data used for all analyses: Tables 1, 2 Analytic code: N/A

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: <http://www.prisma-statement.org/>

Search results

Table S2. Search results; Monday, 13 March 2023

search ID#	Search Terms	Results
Cinhal		
S7	S3 AND S6	211
S6	S4 OR S5	114,099
S5	(MH "Fatty Liver") OR (MH "Nonalcoholic Fatty Liver Disease") OR (MH "Fibrosis") OR (MH "Insulin Resistance+") OR (MH "Glucose Clamp Technique")	46,144
S4	TI ("fatty liver*" OR "NAFLD" OR "NAFL" OR "MAFLD" OR "MAFL" OR "hepatic triglycerides content" OR "steatosis" OR "liver fat" OR "hepatic fat" OR "hepatic lipid" OR ("fatty infiltration" AND (liver OR hepatic)) OR "liver disease*" OR "bright liver" OR "intrahepatocellular lipid" OR "intrahepatocellular fat" OR "ectopic fat" OR "ectopic lipid" OR "steatohepatitis" OR "steato-hepatitis" OR "NASH" OR "liver stiffness" OR "LSM" OR "fibrosis" OR "Insulin resistanc*" OR "insulin sensitivity" OR "insulin insensitivity" OR "insulin intolerance" OR "homeostasis model assessment" OR "HOMA IR" OR "HOMA index" OR "QUICKI" OR "euglycemic clamp" OR "euglycemic glucose clamp" OR "euglycemic-hyperinsulinemic clamp" OR "hyperinsulinemic-euglycemic glucose clamp" OR ("minimal model*" AND (IVGTT OR "intravenous glucose tolerance test"))) OR "metabolic syndrome*" OR "MetS" OR "syndrome x" OR "reaven syndrome*" OR "reaven's syndrome" OR "cardiometabolic syndrome*" OR "cardio-metabolic syndrome*") OR AB ("fatty liver*" OR "NAFLD" OR "NAFL" OR "MAFLD" OR "MAFL" OR "hepatic triglycerides content" OR "steatosis" OR "liver fat" OR "hepatic fat" OR "hepatic lipid" OR ("fatty infiltration" AND (liver OR hepatic)) OR "liver disease*" OR "bright liver" OR "intrahepatocellular lipid" OR "intrahepatocellular fat" OR "ectopic fat" OR "ectopic lipid" OR "steatohepatitis" OR "steato-hepatitis" OR "NASH" OR "liver stiffness" OR "LSM" OR "fibrosis" OR "Insulin resistanc*" OR "insulin sensitivity" OR "insulin insensitivity" OR "insulin intolerance" OR "homeostasis model assessment" OR "HOMA IR" OR "HOMA index" OR "QUICKI" OR "euglycemic clamp" OR "euglycemic glucose clamp" OR "euglycemic-hyperinsulinemic clamp" OR "hyperinsulinemic-euglycemic glucose clamp" OR ("minimal model*" AND (IVGTT OR "intravenous glucose tolerance test"))) OR "metabolic syndrome*" OR "MetS" OR "syndrome x" OR "reaven syndrome*" OR "reaven's syndrome" OR "cardiometabolic syndrome*" OR "cardio-metabolic syndrome*") OR SU ("fatty liver*" OR "NAFLD" OR "NAFL" OR "MAFLD" OR "MAFL" OR "hepatic triglycerides content" OR "steatosis" OR "liver fat" OR "hepatic fat" OR "hepatic lipid" OR ("fatty infiltration" AND (liver OR hepatic)) OR "liver disease*" OR "bright liver" OR "intrahepatocellular lipid" OR "intrahepatocellular fat" OR "ectopic fat" OR "ectopic lipid" OR "steatohepatitis" OR "steato-hepatitis" OR "NASH" OR "liver stiffness" OR "LSM" OR "fibrosis" OR "Insulin resistanc*" OR "insulin sensitivity" OR "insulin insensitivity" OR "insulin intolerance" OR "homeostasis model assessment" OR "HOMA IR" OR "HOMA index" OR "QUICKI" OR "euglycemic clamp" OR "euglycemic glucose clamp" OR "euglycemic-hyperinsulinemic clamp" OR "hyperinsulinemic-euglycemic glucose clamp" OR ("minimal model*" AND (IVGTT OR "intravenous glucose tolerance test"))) OR "metabolic syndrome*" OR "MetS" OR "syndrome x" OR "reaven syndrome*" OR "reaven's syndrome" OR "cardiometabolic syndrome*" OR "cardio-metabolic syndrome*")	113,693
S3	S1 OR S2	7,286
S2	(MH "Food, Commercially Packaged") OR (MH "Fast Foods")	2,143

search ID#	Search Terms	Results
S1	TI ("ultra-processed" OR "UPF" OR "UPFs" OR "ultraprocessed" OR "highly processed" OR "processed food*" OR "processed meal*" OR "processed product*" OR "fast food*" OR "fastfood*" OR "junk food*" OR "ready-to-eat" OR "RTE food*" OR "prepared food*" OR "prepared meal*" OR "ready cooked food*" OR "ready cooked meal*" OR "ready made food*" OR "ready made meal*" OR "convenience food*" OR "convenience meal*" OR "industrialized food*" OR "industrialized meal*" OR "Industrially prepared food*" OR "Industrially prepared meal*") OR AB ("ultra-processed" OR "UPF" OR "UPFs" OR "ultraprocessed" OR "highly processed" OR "processed food*" OR "processed meal*" OR "processed product*" OR "fast food*" OR "fastfood*" OR "junk food*" OR "ready-to-eat" OR "RTE food*" OR "prepared food*" OR "prepared meal*" OR "ready cooked food*" OR "ready cooked meal*" OR "ready made food*" OR "ready made meal*" OR "convenience food*" OR "convenience meal*" OR "industrialized food*" OR "industrialized meal*" OR "Industrially prepared food*" OR "Industrially prepared meal*") OR SU ("ultra-processed" OR "UPF" OR "UPFs" OR "ultraprocessed" OR "highly processed" OR "processed food*" OR "processed meal*" OR "processed product*" OR "fast food*" OR "fastfood*" OR "junk food*" OR "ready-to-eat" OR "RTE food*" OR "prepared food*" OR "prepared meal*" OR "ready cooked food*" OR "ready cooked meal*" OR "ready made food*" OR "ready made meal*" OR "convenience food*" OR "convenience meal*" OR "industrialized food*" OR "industrialized meal*" OR "Industrially prepared food*" OR "Industrially prepared meal*")	7,031
Cochrane		
S15	#14 AND #5	69
S14	#12 OR #13	49262
S13	("fatty liver*" OR "NAFLD" OR "NAFL" OR "MAFLD" OR "MAFL" OR "hepatic triglycerides content" OR "steatosis" OR "liver fat" OR "hepatic fat" OR "hepatic lipid" OR ("fatty infiltration" AND (liver OR hepatic)) OR "liver disease*" OR "bright liver" OR "intrahepatocellular lipid" OR "intrahepatocellular fat" OR "ectopic fat" OR "ectopic lipid" OR "steatohepatitis" OR "steato-hepatitis" OR "NASH" OR "liver stiffness" OR "LSM" OR "fibrosis" OR "Insulin resistanc*" OR "insulin sensitivity" OR "insulin insensitivity" OR "insulin intolerance" OR "homeostasis model assessment" OR "HOMA IR" OR "HOMA index" OR "QUICKI" OR "euglycemic clamp" OR "euglycemic glucose clamp" OR "euglycemic-hyperinsulinemic clamp" OR "hyperinsulinemic-euglycemic glucose clamp" OR ("minimal model*" AND (IVGTT OR "intravenous glucose tolerance test"))) OR "metabolic syndrome*" OR "MetS" OR "syndrome x" OR "reaven syndrome*" OR "reaven's syndrome" OR "cardiometabolic syndrome*" OR "cardio-metabolic syndrome*"):ti,ab,kw	47319
S12	#6 OR #7 OR #8 OR #9 OR #10 OR #11	11931
S11	MeSH descriptor: [Glucose Clamp Technique] this term only	1037
S10	MeSH descriptor: [Metabolic Syndrome] this term only	2391
S9	MeSH descriptor: [Insulin Resistance] this term only	5834
S8	MeSH descriptor: [Fibrosis] this term only	1898
S7	MeSH descriptor: [Non-alcoholic Fatty Liver Disease] this term only	1532
S6	MeSH descriptor: [Fatty Liver] this term only	1114
S5	#3 OR #4	1188
S4	("ultra-processed" OR "UPF" OR "UPFs" OR "ultraprocessed" OR "highly processed" OR "processed food*" OR "processed meal*" OR "processed product*" OR "fast food*" OR "fastfood*" OR "junk food*" OR "ready-to-eat" OR "RTE food*" OR "prepared food*" OR "prepared meal*" OR "ready cooked food*" OR "ready cooked meal*" OR "ready made food*" OR "ready made meal*" OR "convenience food*" OR "convenience meal*" OR "industrialized food*" OR "industrialized meal*" OR "Industrially prepared food*" OR "Industrially prepared meal*"):ti,ab,kw	1117
S3	#1 OR #2	158

search ID#	Search Terms	Results
S2	MeSH descriptor: [Fast Foods] this term only	157
S1	MeSH descriptor: [Food, Processed] this term only	2
Embase		
S7	S5 AND S6	1221
S6	S3 OR S4	873909
S5	S1 OR S2	26262
S4	'fatty liver'/de OR 'metabolic fatty liver'/de OR 'nonalcoholic fatty liver'/de OR 'steatohepatitis'/de OR 'nonalcoholic steatohepatitis'/de OR 'liver fibrosis'/de OR 'insulin resistance'/de OR 'insulin sensitivity'/de OR 'homeostasis model assessment'/de OR 'homa index'/de OR 'quantitative insulin sensitivity check index'/de OR 'hyperinsulinemic-euglycemic clamp technique'/de OR 'metabolic syndrome x'/de	376639
S3	fatty liver*:ti,ab,kw OR 'nafld':ti,ab,kw OR 'nafli':ti,ab,kw OR 'mafld':ti,ab,kw OR 'mafli':ti,ab,kw OR 'hepatic triglycerides content':ti,ab,kw OR 'steatosis':ti,ab,kw OR 'liver fat':ti,ab,kw OR 'hepatic fat':ti,ab,kw OR 'hepatic lipid':ti,ab,kw OR ('fatty infiltration':ti,ab,kw AND (liver:ti,ab,kw OR hepatic:ti,ab,kw)) OR 'liver disease*':ti,ab,kw OR 'bright liver':ti,ab,kw OR 'intrahepatocellular lipid':ti,ab,kw OR 'intrahepatocellular fat':ti,ab,kw OR 'ectopic fat':ti,ab,kw OR 'ectopic lipid':ti,ab,kw OR 'steatohepatitis':ti,ab,kw OR 'steato-hepatitis':ti,ab,kw OR 'nash':ti,ab,kw OR 'liver stiffness':ti,ab,kw OR 'lsm':ti,ab,kw OR 'fibrosis':ti,ab,kw OR 'insulin resistan*':ti,ab,kw OR 'insulin sensitivity':ti,ab,kw OR 'insulin insensitivity':ti,ab,kw OR 'insulin intolerance':ti,ab,kw OR 'homeostasis model assessment':ti,ab,kw OR 'homa ir':ti,ab,kw OR 'homa index':ti,ab,kw OR 'quick'i':ti,ab,kw OR 'euglycemic clamp':ti,ab,kw OR 'euglycemic glucose clamp':ti,ab,kw OR 'euglycemic-hyperinsulinemic clamp':ti,ab,kw OR 'hyperinsulinemic-euglycemic glucose clamp':ti,ab,kw OR ('minimal model*':ti,ab,kw AND (ivgtt:ti,ab,kw OR 'intravenous glucose tolerance test':ti,ab,kw)) OR 'metabolic syndrome*':ti,ab,kw OR 'mets':ti,ab,kw OR 'syndrome x':ti,ab,kw OR 'reaven syndrome*':ti,ab,kw OR 'reaven/s syndrome':ti,ab,kw OR 'cardiometabolic syndrome*':ti,ab,kw OR 'cardio-metabolic syndrome*':ti,ab,kw	802678
S2	'ultra-processed food'/de OR 'processed food'/de OR 'convenience food'/de OR 'fast food'/de OR 'junk food'/de	12714
S1	'ultra-processed':ti,ab,kw OR 'upf':ti,ab,kw OR 'upfs':ti,ab,kw OR 'ultraprocessed':ti,ab,kw OR 'highly processed':ti,ab,kw OR 'processed food*':ti,ab,kw OR 'processed meal*':ti,ab,kw OR 'processed product*':ti,ab,kw OR 'fast food*':ti,ab,kw OR 'fastfood*':ti,ab,kw OR 'junk food*':ti,ab,kw OR 'ready-to-eat':ti,ab,kw OR 'rte food*':ti,ab,kw OR 'prepared food*':ti,ab,kw OR 'prepared meal*':ti,ab,kw OR 'ready cooked food*':ti,ab,kw OR 'ready cooked meal*':ti,ab,kw OR 'ready made food*':ti,ab,kw OR 'ready made meal*':ti,ab,kw OR 'convenience food*':ti,ab,kw OR 'convenience meal*':ti,ab,kw OR 'industrialized food*':ti,ab,kw OR 'industrialized meal*':ti,ab,kw OR 'industrially prepared food*':ti,ab,kw OR 'industrially prepared meal*':ti,ab,kw	20432
PubMed		
S7	#5 AND #6	540
S6	#2 OR #4	550,544
S5	#1 OR #3	17,305
S4	(((((("Fatty Liver"[Mesh:NoExp]) OR "Non-alcoholic Fatty Liver Disease"[Mesh:NoExp]) OR "Fibrosis"[Mesh:NoExp]) OR "Insulin Resistance"[Mesh:NoExp]) OR "Metabolic Syndrome"[Mesh:NoExp]) OR "Glucose Clamp Technique"[Mesh:NoExp]	174,459

search ID#	Search Terms	Results
S3	("Food, Processed"[Mesh:NoExp]) OR "Fast Foods"[Mesh:NoExp]	3,037
S2	"fatty liver"[Title/Abstract] OR "NAFLD"[Title/Abstract] OR "NAFL"[Title/Abstract] OR "MAFLD"[Title/Abstract] OR "MAFL"[Title/Abstract] OR "hepatic triglycerides content"[Title/Abstract] OR "steatosis"[Title/Abstract] OR "liver fat"[Title/Abstract] OR "hepatic fat"[Title/Abstract] OR "hepatic lipid"[Title/Abstract] OR ("fatty infiltration"[Title/Abstract] AND (liver[Title/Abstract] OR hepatic[Title/Abstract])) OR "liver disease"[Title/Abstract] OR "bright liver"[Title/Abstract] OR "intrahepatocellular lipid"[Title/Abstract] OR "intrahepatocellular fat"[Title/Abstract] OR "ectopic fat"[Title/Abstract] OR "ectopic lipid"[Title/Abstract] OR "steatohepatitis"[Title/Abstract] OR "steato-hepatitis"[Title/Abstract] OR "NASH"[Title/Abstract] OR "liver stiffness"[Title/Abstract] OR "LSM"[Title/Abstract] OR "fibrosis"[Title/Abstract] OR "Insulin resistan"[Title/Abstract] OR "insulin sensitivity"[Title/Abstract] OR "insulin insensitivity"[Title/Abstract] OR "insulin intolerance"[Title/Abstract] OR "homeostasis model assessment"[Title/Abstract] OR "HOMA IR"[Title/Abstract] OR "HOMA index"[Title/Abstract] OR "QUICKI"[Title/Abstract] OR "euglycemic clamp"[Title/Abstract] OR "euglycemic glucose clamp"[Title/Abstract] OR "euglycemic-hyperinsulinemic clamp"[Title/Abstract] OR "hyperinsulinemic-euglycemic glucose clamp"[Title/Abstract] OR ("minimal model"[Title/Abstract] AND (IVGTT[Title/Abstract] OR "intravenous glucose tolerance test"[Title/Abstract])) OR "metabolic syndrome"[Title/Abstract] OR "MetS"[Title/Abstract] OR "syndrome x"[Title/Abstract] OR "reaven syndrome"[Title/Abstract] OR "reaven's syndrome"[Title/Abstract] OR "cardiometabolic syndrome"[Title/Abstract] OR "cardio-metabolic syndrome"[Title/Abstract]	525,309
S1	"ultra-processed"[Title/Abstract] OR "UPF"[Title/Abstract] OR "UPFs"[Title/Abstract] OR "ultraprocessed"[Title/Abstract] OR "highly processed"[Title/Abstract] OR "processed food"[Title/Abstract] OR "processed meal"[Title/Abstract] OR "processed product"[Title/Abstract] OR "fast food"[Title/Abstract] OR "fastfood"[Title/Abstract] OR "junk food"[Title/Abstract] OR "ready-to-eat"[Title/Abstract] OR "RTE food"[Title/Abstract] OR "prepared food"[Title/Abstract] OR "prepared meal"[Title/Abstract] OR "ready cooked food"[Title/Abstract] OR "ready cooked meal"[Title/Abstract] OR "ready made food"[Title/Abstract] OR "ready made meal"[Title/Abstract] OR "convenience food"[Title/Abstract] OR "convenience meal"[Title/Abstract] OR "industrialized food"[Title/Abstract] OR "industrialized meal"[Title/Abstract] OR "Industrially prepared food"[Title/Abstract] OR "Industrially prepared meal"[Title/Abstract]	16,587
Scopus		
S3	S1 AND S2	1,019
S2	(TITLE-ABS-KEY ("fatty liver" OR "nafld" OR "nafl" OR "mafld" OR "mafl" OR "hepatic triglycerides content" OR "steatosis" OR "liver fat" OR "hepatic fat" OR "hepatic lipid" OR ("fatty infiltration" AND (liver OR hepatic)) OR "liver disease") OR TITLE-ABS-KEY ("bright liver" OR "intrahepatocellular lipid" OR "intrahepatocellular fat" OR "ectopic fat" OR "ectopic lipid" OR "steatohepatitis" OR "steato-hepatitis" OR "nash" OR "liver stiffness" OR "lsm" OR "fibrosis") OR TITLE-ABS-KEY ("insulin resistan" OR "insulin sensitivity" OR "insulin insensitivity" OR "insulin intolerance" OR "homeostasis model assessment" OR "homa ir" OR "homa index" OR "quickl" OR "euglycemic clamp" OR "euglycemic glucose clamp" OR "euglycemic-hyperinsulinemic clamp" OR "hyperinsulinemic-euglycemic glucose clamp") OR TITLE-ABS-KEY (("minimal model" AND (ivgtt OR "intravenous glucose tolerance test")) OR "metabolic syndrome" OR "mets" OR "syndrome x" OR "reaven syndrome" OR "reaven's syndrome" OR "cardiometabolic syndrome" OR "cardio-metabolic syndrome")))	878,126
S1	(TITLE-ABS-KEY ("ultra-processed" OR "upf" OR "upfs" OR "ultraprocessed" OR "highly processed" OR "processed food" OR "processed meal" OR "processed product" OR "fast food") OR TITLE-ABS-KEY ("fastfood" OR "junk food" OR "ready-to-eat" OR "rte food" OR "prepared food" OR "prepared meal" OR "ready cooked food") OR TITLE-ABS-KEY ("ready cooked meal" OR "ready made food" OR "ready made meal" OR "convenience food" OR "convenience meal" OR "industrialized food" OR "industrialized meal" OR "industrially prepared food" OR "industrially prepared meal"))	41,849

search ID#	Search Terms	Results
Web of science		
S1	<p>"ultra-processed" OR "UPF" OR "UPFs" OR "ultraprocessed" OR "highly processed" OR "processed food*" OR "processed meal*" OR "processed product*" OR "fast food*" OR "fastfood*" OR "junk food*" OR "ready-to-eat" OR "RTE food*" OR "prepared food*" OR "prepared meal*" OR "ready cooked food*" OR "ready cooked meal*" OR "ready made food*" OR "ready made meal*" OR "convenience food*" OR "convenience meal*" OR "industrialized food*" OR "industrialized meal*" OR "Industrially prepared food*" OR "Industrially prepared meal*" (Topic) AND "fatty liver*" OR "NAFLD" OR "NAFL" OR "MAFLD" OR "MAFL" OR "hepatic triglycerides content" OR "steatosis" OR "liver fat" OR "hepatic fat" OR "hepatic lipid" OR ("fatty infiltration" AND (liver OR hepatic)) OR "liver disease*" OR "bright liver" OR "intrahepatocellular lipid" OR "intrahepatocellular fat" OR "ectopic fat" OR "ectopic lipid" OR "steatohepatitis" OR "steato-hepatitis" OR "NASH" OR "liver stiffness" OR "LSM" OR "fibrosis" OR "Insulin resistanc*" OR "insulin sensitivity" OR "insulin insensitivity" OR "insulin intolerance" OR "homeostasis model assessment" OR "HOMA IR" OR "HOMA index" OR "QUICKI" OR "euglycemic clamp" OR "euglycemic glucose clamp" OR "euglycemic-hyperinsulinemic clamp" OR "hyperinsulinemic-euglycemic glucose clamp" OR ("minimal model*" AND (IVGTT OR "intravenous glucose tolerance test")) OR "metabolic syndrome*" OR "MetS" OR "syndrome x" OR "reaven syndrome*" OR "reaven's syndrome" OR "cardiometabolic syndrome*" OR "cardio-metabolic syndrome*" (Topic)</p>	916

keyword search strategy

PubMed; Cochrane; CINAHL; EMBASE; Web of Science; Scopus

Concept #1

“ultra-processed” OR “UPF” OR “UPFs” OR “ultraprocessed” OR “highly processed” OR “processed food” OR “processed meal*” OR “processed product*” OR “fast food*” OR “fastfood*” OR “junk food*” OR “ready-to-eat” OR “RTE food*” OR “prepared food*” OR “prepared meal*” OR “ready cooked food*” OR “ready cooked meal*” OR “ready made food*” OR “ready made meal*” OR “convenience food*” OR “convenience meal*” OR “industrialized food*” OR “industrialized meal*” OR “Industrially prepared food*” OR “Industrially prepared meal*”*

AND

Concept #2

“fatty liver” OR “NAFLD” OR “NAFL” OR “MAFLD” OR “MAFL” OR “hepatic triglycerides content” OR “steatosis” OR “liver fat” OR “hepatic fat” OR “hepatic lipid” OR (“fatty infiltration” AND (liver OR hepatic)) OR “liver disease*” OR “bright liver” OR “intrahepatocellular lipid” OR “intrahepatocellular fat” OR “ectopic fat” OR “ectopic lipid” OR “steatohepatitis” OR “steato-hepatitis” OR “NASH” OR “liver stiffness” OR “LSM” OR “fibrosis” OR “Insulin resistanc*” OR “insulin sensitivity” OR “insulin insensitivity” OR “insulin intolerance” OR “homeostasis model assessment” OR “HOMA IR” OR “HOMA index” OR “QUICKI” OR “euglycemic clamp” OR “euglycemic glucose clamp” OR “euglycemic-hyperinsulinemic clamp” OR “hyperinsulinemic-euglycemic glucose clamp” OR (“minimal model*” AND (IVGTT OR “intravenous glucose tolerance test”)) OR “metabolic syndrome*” OR “MetS” OR “syndrome x” OR “reaven syndrome*” OR “reaven’s syndrome” OR “cardiometabolic syndrome*” OR “cardio-metabolic syndrome*”*

Table S3. Controlled vocabulary thesauruses for relevant databases

PubMed \Cochrane MeSH Database	CINAHL CINAHL Subject Headings	EMBASE Emtree
<p>Concept #1 Food, Processed (MeSH) Fast Foods (MeSH)</p> <p>AND</p> <p>Concept #2 Fatty Liver (MeSH) Non-alcoholic Fatty Liver Disease (MeSH) Fibrosis (MeSH) Insulin Resistance (MeSH) Metabolic Syndrome (MeSH) Glucose Clamp Technique (MeSH)</p>	<p>Concept #1 Food, Commercially Packaged (Index Term) Fast Foods (Index Term)</p> <p>AND</p> <p>Concept #2 Fatty Liver (Index Term) Nonalcoholic Fatty Liver Disease (Index Term) Fibrosis (Index Term) Insulin Resistance (Index Term exp) Glucose Clamp Technique (Index Term)</p>	<p>Concept #1 Ultra-processed food (EMTREE) Processed food (EMTREE) convenience food (EMTREE) fast food (EMTREE) junk food (EMTREE)</p> <p>AND</p> <p>Concept #2 Fatty liver (EMTREE) Metabolic fatty liver (EMTREE) Nonalcoholic fatty liver (EMTREE) Steatohepatitis (EMTREE) Nonalcoholic steatohepatitis (EMTREE) Liver fibrosis (EMTREE) Insulin resistance (EMTREE) Insulin sensitivity (EMTREE) Homeostasis model assessment (EMTREE) HOMA index (EMTREE) Quantitative Insulin Sensitivity Check Index (EMTREE) Hyperinsulinemic-euglycemic clamp technique (EMTREE) Metabolic syndrome X (EMTREE)</p>

Excluded full text articles

Table S4. Excluded full-text articles, including detailed reasons for their exclusion

Article, by first author (year)	Main reason for exclusion ¹
Krupp K. (2020) (20)	2
Kurniawan AL (2020) (21)	1
Lee YQ. (2022) (22)	3
Longo GZ. (2022) (23)	1
Martinez-Perez C. (2021) (24)	3
Migliaretti G. (2020) (25)	6
Naja F. (2013) (26)	1
Nakashita C. (2021) (27)	1
Odegaard AO. (2022) (28)	2
Kalafati IP. (2019) (29)	1
Lopes-Pinto S. (2019) (30)	6
Santana GJ. (2021) (31)	3
Sayegh NF. (2022) (32)	1
Talenezhad N. (2022) (33)	1
Ushula TW. (2022) (34)	1
Walker MS. (2022) (35)	5
Yin X. (2020) (36)	1
Zhang T. (2021) (37)	5
Zhang ZF. (2021) (38)	3

Article, by first author (year)	Main reason for exclusion ¹
Azevedo VZ. (2021) (1)	2
Barker K. (2021) (2)	4
Choi YI. (2020) (3)	4
Cloward J. (2022) (4)	4
Dehghanseresht N. (2020) (5)	1
Duval C. (2017) (6)	6
Eslamian, G. (2017) (7)	4
Fakhoury-Sayegh N. (2017) (8)	1
Gadgil MD. (2015) (9)	1
Giacomello L. (2023) (10)	6
Griffin J. (2021) (11)	3
Heidemann C. (2011) (12)	1
Hosseini Z. (2021) (13)	1
Hu E. (2022) (14)	4
Johnson-Down L. (2015) (15)	1
Juul F. (2021) (16)	3
Kardashian A. (2022) (17)	2
Kardashian A. (2023) (18)	2
Konieczna J. (2021) (19)	5

¹Main reasons for exclusion: (1) Unspecified classification - not based on processing level, n=15; (2) Did not assess UPF as a whole (only subgroups, as junk food or processed meat), n=5; (3) For MetS outcome - studies that did not assess MetS as a whole (only metabolic components separately or other cardiovascular risk indices), n=6; (4) Letters, editorials, meeting abstracts or reviews, n=5; (5) Inappropriate outcome (other), n=3; (6) Inappropriate exposure (other), n=4.

Quality assessment

Table S5.A. The Joanna Briggs Institute’s critical appraisal tool for included observational studies with NAFLD outcome (n=5)

Author (year)	Scoring Criteria											
	1	2	3	4	5	6	7	8	9	10	11	
Prospective¹												
1. Zhang S. (2022)	1	1	1	1	1	1	1	1	1	1	1	1
2. Konieczna J. (2022)	1	1	1	1	1	0	0	1	1	1	1	1
Cross-sectional²												
1. Liu Z. (2022)	1	1	1	1	1	1	0	1				
2. Friden M. (2022)	0	1	1	1	1	1	1	1				
3. Ivancovsky-Wajcman D. (2021)	1	1	1	1	1	1	1	1				

Table S5.B. The Joanna Briggs Institute’s critical appraisal tool for included observational studies with IR and MetS outcomes (n=11)

Author (year)	Scoring Criteria											
	1	2	3	4	5	6	7	8	9	10	11	
Prospective¹												
1. Canhada SL. (2023)	1	1	1	1	1	1	1	1	1	1	1	1
2. Pan F. (2023)	1	1	1	1	1	1	1	1	1	1	1	1
3. Magalhães EIDS. (2022)	1	1	0	1	1	1	0	1	1	1	1	1

Cross-sectional²

1. Bezerra Barbosa L. (2023)	1	1	1	1	1	1	0	1
2. Liu Z. (2022)	1	1	1	1	1	1	1	1
3. Silva Meneguelli T. (2022)	1	1	1	0	1	1	0	1
4. Hosseininasab D. (2022)	0	1	1	1	1	1	1	0
5. Ivancovsky-Wajcman D. (2021)	1	1	1	1	1	1	1	1
6. Martinez Steele E. (2019)	1	1	1	1	1	1	1	1
7. Lavigne-Robichaud M. (2018)	1	1	1	1	1	1	1	1
8. Nasreddine L. (2018)	1	1	0	1	1	1	1	1

¹Joanna Briggs Institute (JBI) cohort studies critical appraisal tool. The scoring criteria were as follows: 1. Were the two groups similar and recruited from the same population? 2. Were the exposures measured similarly to assign people to both exposed and unexposed groups? 3. Was the exposure measured in a valid and reliable way? 4. Were confounding factors identified? 5. Were strategies to deal with confounding factors stated? 6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)? 7. Were the outcomes measured in a valid and reliable way? 8. Was the follow up time reported and sufficient to be long enough for outcomes to occur? 9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored? 10. Were strategies to address incomplete follow up utilized? 11. Was appropriate statistical analysis used? yes: 1, no/ unclear/ not applicable: 0

²Joanna Briggs Institute (JBI) analytical cross sectional studies critical appraisal tool. The scoring criteria were as follows: 1. Were the criteria for inclusion in the sample clearly defined? 2. Were the study subjects and the setting described in detail? 3. Was the exposure measured in a valid and reliable way? 4. Were objective, standard criteria used for measurement of the condition? 5. Were confounding factors identified? 6. Were strategies to deal with confounding factors stated? 7. Were the outcomes measured in a valid and reliable way? 8. Was appropriate statistical analysis used? yes: 1, no/ unclear/ not applicable: 0

Table S6. The Cochrane Collaboration’s tool for risk of bias in randomized control trials (RoB 2 tool) (n=1)

Domain	Signalling question	Response
Bias arising from the randomization process	1.1 Was the allocation sequence random?	Y
	1.2 Was the allocation sequence concealed until participants were enrolled and assigned to interventions?	PY
	1.3 Did baseline differences between intervention groups suggest a problem with the randomization process?	N
	Risk of bias judgement	Low
Domain S: Risk of bias arising from period and carryover effects	S.1 Was the number of participants allocated to each of the two sequences equal or nearly equal?	NI
	S.2 If N/PN/NI to S.1: Were period effects accounted for in the analysis?	NI
	S.3 Was there sufficient time for any carryover effects to have disappeared before outcome assessment in the second period?	NI
	Risk of bias judgement	Some concerns
Bias due to deviations from intended interventions	2.1. Were participants aware of their assigned intervention during the trial?	PY
	2.2. Were carers and people delivering the interventions aware of participants' assigned intervention during the trial?	PY
	2.3. If Y/PY/NI to 2.1 or 2.2: Were there deviations from the intended intervention that arose because of the experimental context?	N
	2.4 If Y/PY to 2.3: Were these deviations likely to have affected the outcome?	NA
	2.5. If Y/PY/NI to 2.4: Were these deviations from intended intervention balanced between groups?	NA
	2.6 Was an appropriate analysis used to estimate the effect of assignment to intervention?	Y
	2.7 If N/PN/NI to 2.6: Was there potential for a substantial impact (on the result) of the failure to analyse participants in the group to which they were randomized?	NA
	Risk of bias judgement	Low
Bias due to missing outcome data	3.1 Were data for this outcome available for all, or nearly all, participants randomized?	N
	3.2 If N/PN/NI to 3.1: Is there evidence that result was not biased by missing outcome data?	N
	3.3 If N/PN to 3.2: Could missingness in the outcome depend on its true value?	N
	3.4 If Y/PY/NI to 3.3: Is it likely that missingness in the outcome depended on its true value?	NA
	Risk of bias judgement	Low

Domain	Signalling question	Response
Bias in measurement of the outcome	4.1 Was the method of measuring the outcome inappropriate?	N
	4.2 Could measurement or ascertainment of the outcome have differed between intervention groups?	N
	4.3 Were outcome assessors aware of the intervention received by study participants?	NI
	4.4 If Y/PY/NI to 4.3: Could assessment of the outcome have been influenced by knowledge of intervention received?	PN
	4.5 If Y/PY/NI to 4.4: Is it likely that assessment of the outcome was influenced by knowledge of intervention received?	NA
	Risk of bias judgement	Low
Bias in selection of the reported result	5.1 Were the data that produced this result analysed in accordance with a pre-specified analysis plan that was finalized before unblinded outcome data were available for analysis?	PY
	5.2 ... multiple eligible outcome measurements (e.g. scales, definitions, time points) within the outcome domain?	N
	5.3 ... multiple eligible analyses of the data?	N
	5.4 Is a result based on data from both periods sought, but unavailable on the basis of carryover having been identified?	N
	Risk of bias judgement	Low
Overall bias	Risk of bias judgement	Some concerns

References

1. Azevedo VZ, Dall'Alba V. Fructose intake is not associated to the risk of hepatic fibrosis in patients with Non-Alcoholic Fatty Liver Disease (NAFLD). *Clinical Nutrition*. 2021;40(6):4275-83.
2. Barker K, Davy B. Is Consumption of Ultra-Processed Foods Associated with Cardiometabolic Risk? *Scan's Pulse*. 2021;41(1):1-5.
3. Choi YI. Prospective association between ultra-processed food consumption and risk of non-alcoholic fatty liver disease: A nationwide long-term follow up study. *United European Gastroenterology Journal*. 2020;8(8 SUPPL):125.
4. Cloward J, vliet Sv. Consumption of an Ultra-Processed Diet Negatively Alters Biomarkers of Metabolic Health Compared to An Unprocessed Diet: A 4-Week Randomized Controlled Diet...The Academy of Nutrition and Dietetics Food & Nutrition Conference & Expo, October 8-11, 2022, Orlando, Florida. *Journal of the Academy of Nutrition & Dietetics*. 2022;122(10):A123-A.
5. Dehghanseresht N, Jafarirad S, Alavinejad SP, Mansoori A. Association of the dietary patterns with the risk of non-alcoholic fatty liver disease among Iranian population: a case-control study. *Nutrition Journal*. 2020;19(1):63.
6. Duval C, Rouillier MA, Rabasa-Lhoret R, Karelis AD. High Intensity Exercise: Can It Protect You from A Fast Food Diet? *Nutrients*. 2017;9(9):943.
7. Eslamian G, Shakeri M. Dietary patterns in relation to nonalcoholic fatty liver disease [Conference Abstract]. *Hepatitis Monthly*. 2017;17:32.
8. Fakhoury-Sayegh N, Younes H, Heraoui GNHA, Sayegh R. Nutritional profile and dietary patterns of lebanese non-alcoholic fatty liver disease patients: A case-control study. *Nutrients*. 2017;9(11):1245.
9. Gadgil MD, Anderson CAM, Kandula NR, Kanaya AM. Dietary patterns are associated with metabolic risk factors in south Asians living in the United States. *Journal of Nutrition*. 2015;145(6):1211-7.
10. Giacomello L, Bordignon S, Salm D, Donatello N, Belmonte LA, Bobinski F, et al. Effects of the application of a food processing-based classification system in obese women: a randomized controlled pilot study. *Nutrition and health (Berkhamsted, Hertfordshire)*. 2023;7:2601060231153947.
11. Griffin J, Albaloul A, Kopytek A, Elliott P, Frost G. Effect of ultraprocessed food intake on cardiometabolic risk is mediated by diet quality: a cross-sectional study. *BMJ Nutr Prev Health*. 2021;4(1):174-80.
12. Heidemann C, Scheidt-Nave C, Richter A, Mensink GB. Dietary patterns are associated with cardiometabolic risk factors in a representative study population of German adults. *Br J Nutr*. 2011;106(8):1253-62.
13. Hosseini Z, Rostami M, Whiting SJ, Vatanparast H. Fast-Food Dietary Pattern Is Linked to Higher Prevalence of Metabolic Syndrome in Older Canadian Adults. *J Nutr Metab*. 2021;2021:5712844.
14. Hu E, Capelli G, Saeian K, Loy V, Trivella J, Esteban JP. FREQUENT FAST FOOD CONSUMPTION IS ASSOCIATED WITH MORE SEVERE NON-ALCOHOLIC FATTY LIVER DISEASE, WHILE HIGH-QUALITY, HOME-PREPARED MEALS MAY BE PROTECTIVE [Conference Abstract]. *Gastroenterology*. 2022;162(7):S1207-S8.

15. Johnson-Down L, Labonte ME, Martin ID, Tsuji LJ, Nieboer E, Dewailly E, et al. Quality of diet is associated with insulin resistance in the Cree (Eeyouch) indigenous population of northern Québec. *Nutr Metab Cardiovasc Dis*. 2015;25(1):85-92.
16. Juul F, Vaidean G, Lin Y, Deierlein AL, Parekh N. Ultra-Processed Foods and Incident Cardiovascular Disease in the Framingham Offspring Study. *Journal of the American College of Cardiology*. 2021;77(12):1520-31.
17. Kardashian A, Dodge JL, Terrault NA. Quantifying the Negative Impact of Fast-Food Consumption on Liver Steatosis Among U.S. Adults in the General Population. *Official journal of the American College of Gastroenterology*. 2022;117(10):e896-e7.
18. Kardashian A, Dodge JL, Terrault NA. Quantifying the Negative Impact of Fast-food Consumption on Liver Steatosis Among United States Adults with Diabetes and Obesity. *Clinical Gastroenterology and Hepatology*. 2023;S1542-3565(22):01137-5.
19. Konieczna J, Morey M, Abete I, Bes-Rastrollo M, Ruiz-Canela M, Vioque J, et al. Contribution of ultra-processed foods in visceral fat deposition and other adiposity indicators: Prospective analysis nested in the PREDIMED-Plus trial. *Clin Nutr*. 2021;40(6):4290-300.
20. Krupp K, Adsul P, Wilcox ML, Srinivas V, Frank E, Srinivas A, et al. Prevalence and correlates of metabolic syndrome among rural women in Mysore, India. *Indian Heart J*. 2020;72(6):582-8.
21. Kurniawan AL, Hsu CY, Lee HA, Rau HH, Paramastri R, Syauqy A, et al. Comparing two methods for deriving dietary patterns associated with risk of metabolic syndrome among middle-aged and elderly Taiwanese adults with impaired kidney function. *BMC Med Res Methodol*. 2020;20(1):255.
22. Lee YQ, Whitton C, Neelakantan N, van Dam RM, Chong MFF. Dietary patterns and predicted 10-year cardiovascular disease risk in a multiethnic Asian population. *Nutrition Metabolism and Cardiovascular Diseases*. 2022;32(9):2093-104.
23. Longo GZ, Ordaz KD, da Silva DCG, Hinnig PF, Roberto DMT, Reinert C, et al. Dietary patterns and cardiovascular risk factors among Brazilians: A population-based study in Viçosa, Minas Gerais. *Nutrition*. 2022;98:111626.
24. Martinez-Perez C, San-Cristobal R, Guallar-Castillon P, Martínez-González M, Salas-Salvadó J, Corella D, et al. Use of Different Food Classification Systems to Assess the Association between Ultra-Processed Food Consumption and Cardiometabolic Health in an Elderly Population with Metabolic Syndrome (PREDIMED-Plus Cohort). *Nutrients*. 2021;13(7):2471.
25. Migliaretti G, Ame C, Ciullo S, Fontana E, Stura I, Nano E, et al. Metabolic and psychological effects of short-term increased consumption of less-processed foods in daily diets: a Pilot Study. *Diabetes & metabolism*. 2020;46(1):66-9.
26. Naja F, Nasreddine L, Itani L, Adra N, Sibai A, Hwalla N. Association between dietary patterns and the risk of metabolic syndrome among Lebanese adults. *European Journal of Nutrition*. 2013;52(1):97-105.
27. Nakashita C, Xi L, Inoue Y, Kabura R, Masuda S, Yamano Y, et al. Impact of dietary compositions and patterns on the prevalence of nonalcoholic fatty liver disease in Japanese men: a cross-sectional study. *BMC Gastroenterology*. 2021;21(1):342.
28. Odegaard AO, Jacobs DR, Van Wagner LB, Pereira MA. Levels of abdominal adipose tissue and metabolic-associated fatty liver disease (MAFLD) in middle age according to average fast-food intake over the preceding 25 years: the CARDIA Study. *American Journal of Clinical Nutrition*. 2022;116(1):255-62.

29. Kalafati IP, Borsa D, Dimitriou M, Revenas K, Kokkinos A, Dedoussis GV. Dietary patterns and non-alcoholic fatty liver disease in a Greek case-control study. *Nutrition*. 2019;61:105-10.
30. Lopes Pinto S, da Silva DCG, Bressan J. Absolute and Relative Changes in Ultra-processed Food Consumption and Dietary Antioxidants in Severely Obese Adults 3 Months After Roux-en-Y Gastric Bypass. *Obes Surg*. 2019;29(6):1810-5.
31. Santana GJ, Silva NJ, Costa JO, Vásquez CMP, Vila-Nova TMS, Vieira D, et al. Contribution of minimally processed and ultra-processed foods to the cardiometabolic risk of Brazilian young adults: a cross-sectional study. *Nutr Hosp*. 2021;38(2):328-36.
32. Sayegh NF, Heraoui G, Younes H, Sayegh LN, Boulos C, Sayegh R. Relation of Dietary Patterns and Nutritional Profile to Hepatic Fibrosis in a Sample of Lebanese Non-Alcoholic Fatty Liver Disease Patients. *Nutrients*. 2022;14(12):2554.
33. Talenezhad N, Mirzavandi F, Rahimpour S, Amel Shahbaz AP, Mohammadi M, Hosseinzadeh M. Empirically derived dietary pattern and odds of non-alcoholic fatty liver diseases in overweight and obese adults: a case-control study. *BMC Gastroenterol*. 2022;22(1):158.
34. Ushula TW, Mamun A, Darssan D, Wang WYS, Williams GM, Whiting SJ, et al. Dietary patterns and the risks of metabolic syndrome and insulin resistance among young adults: Evidence from a longitudinal study. *Clin Nutr*. 2022;41(7):1523-31.
35. Walker MS, Tarasiuk FS, Gustavo AS, Oliveira MS, Donadio MVF, Feoli AMP. Lifestyle improvement reduces the consumption of ultra-processed foods in adults with metabolic syndrome. *Nutrition, metabolism, and cardiovascular diseases*. 2022;32(8):1990-7.
36. Yin X, Chen Y, Lu W, Jin T, Li L. Association of dietary patterns with the newly diagnosed diabetes mellitus and central obesity: a community based cross-sectional study. *Nutr Diabetes*. 2020;10(1):16.
37. Zhang T, Gan S, Ye M, Meng G, Zhang Q, Liu L, et al. Association between consumption of ultra-processed foods and hyperuricemia: TCLSIH prospective cohort study. *Nutrition, Metabolism and Cardiovascular Diseases*. 2021;31(7):1993-2003.
38. Zhang ZF, Jackson SL, Martinez E, Gillespie C, Yang QH. Association between ultraprocessed food intake and cardiovascular health in US adults: a cross-sectional analysis of the NHANES 2011-2016. *American Journal of Clinical Nutrition*. 2021;113(2):428-36.