Cardiovascular health metrics and the risk of metabolic dysfunction-associated steatosis liver disease: A meta-analysis

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Received April 28, 2026; Accepted August 4, 2026

DOI: 10.3892/etm.2026.13297

Abstract. The present study aimed to ascertain the associations between the Life's Essential 8 (LE8) score and metabolic dysfunction-associated steatosis liver disease (MASLD) risk. The PubMed, Scopus and Cochrane library databases were searched from inception to December 2025. Data synthesis was performed using R software. The final analysis incorporated five observational studies, encompassing a total of 36,187 participants aged 18 to 70 years. The results showed that a moderate LE8 score was associated with a lower risk of MASLD compared to a low LE8 score [odds ratio (OR)=0.36, 95% confidence interval (CI): 0.25-0.52]. Furthermore, compared to the low LE8 score, a high LE8 score was indicative of a decreased risk of MASLD (OR=0.07, 95% CI: 0.02-0.19). In conclusion, this meta-analysis suggests that favorable cardiovascular health metrics may confer protection against MASLD. However, the substantial heterogeneity observed across the included studies warrants a cautious interpretation of these findings.

Introduction

Metabolic dysfunction-associated steatosis liver disease (MASLD) plays a significant role in the prevalence of chronic liver disease (1). The results of epidemiological studies have demonstrated that liver transplantation is increasingly being performed due to MASLD, which has now become the second most prevalent reason for this life-saving procedure in the United States (2). The rise of MASLD prevalence is associated with economic and social development, sedentary lifestyles and the consumption of high-fat and high-calorie diets. It can be reasonably deduced from the most recent statistical data that the global prevalence of MASLD is 25% (3). MASLD is a degenerative disease resulting from lipid droplet accumulation in hepatocytes. Lipid droplets can induce an inflammatory response, apoptosis and even progression to cirrhosis and liver cancer (4). Although liver-related complications elevate the mortality rate of MASLD, cardiovascular disease (CVD) remains the predominant cause of death in patients with MASLD (5). The interaction between MASLD and cardiovascular health has received significant attention in recent years. However, the exact relationship and respective roles remain incompletely understood.

The Life's Essential 8 (LE8), a recently updated cardiovascular health concept introduced and promoted by the American Heart Association (AHA), serves as an efficacious predictor of the risk of developing CVD and other chronic conditions (6). According to the AHA guidelines, LE8 scores between 80 and 100 indicate good cardiovascular health, scores between 50 and 79 suggest moderate and scores between 0 and 49 reflect poor cardiovascular health (6). LE8 is an extension of Life's simple 7 (LS7), which takes into account ideal health behaviors [such as minimal nicotine exposure, a body mass index (BMI) of <25 kg/m^2, optimal physical activity and diets in accordance with recommended guidelines] and health factors [including normal serum lipid, blood pressure (BP) and blood glucose levels], as well as the crucial aspect of sleep health (7). Existing research indicates a potential negative link between sleep quality and chronic liver disease (8,9). However, there is limited information on the connection between LE8 and MASLD, and the exact nature of this relationship and its impact on MASLD has remained to be fully elucidated. Given these gaps in knowledge, the present study undertook a thorough meta-analysis to investigate the associations between the LE8 score and the risk of MASLD.

Materials and methods

Guidelines and ethics. The present study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (10). The study utilized publicly available data, eliminating the need for ethical approval or patient consent. This study was not registered.

Search strategy. A systematic literature search was conducted by two authors (GF and HZ) in the PubMed (www.pubmed.

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Key words: cardiovascular health, MASLD, Life's Essential 8, meta-analysis

ncbi.nlm.nih.gov), Scopus (www.scopus.com) and Cochrane Library databases (www.cochrane.org) from inception until December 2025. Furthermore, a comprehensive review of the reference lists of the retrieved articles was performed to identify any additional pertinent studies that may have been overlooked in the primary database searches. The following terms were used in the search: 'Nonalcoholic fatty liver disease', 'Cardiovascular health', 'Life's essential 8', 'MASLD', 'LE8' and 'Hepatic disease'. The search strategy in PubMed used the following terms: '((Life's essential 8[Title/Abstract]) OR (LE8[Title/Abstract])) AND (((Nonalcoholic fatty liver disease [Title/Abstract]) OR (Hepatic disease [Title/Abstract])) OR (MASLD[Title/Abstract]))'.

Study selection. After completing the database search, the references were imported into EndNote software (version x9.3.2; Clarivate Analytics) and duplicate entries were removed. Next, the titles and abstracts were screened and only those articles that met the criteria were selected (Fig. 1). The studies were evaluated independently by at least two reviewers (GF and HZ) based on predetermined inclusion and exclusion criteria. Any discrepancies that arose at any point were resolved through discussion with a third investigator (BL).

The study's focus was to examine association between LE8 and the occurrence of MASLD. To guarantee a deep and complete analysis, the inclusion criteria encompassed observational studies that explored the effects of the AHA's newly introduced LE8 metrics on MASLD. The review included cohort, cross-sectional or case-control studies. The study population was limited to individuals aged 18 years and older, excluding minors from participation. The review excluded certain studies due to specific criteria, including case reports, editorials, literature reviews and conference abstracts. Furthermore, studies published in languages other than English and animal studies were not included in the analysis.

Data extraction. A total of two independent reviewers (GF and HZ) used a predefined form to collect data from the included studies. The information gathered included the primary author, publication journal, publication year, participant age, participant count, male proportion, odds ratio (OR), 95% confidence interval (CI) and follow-up duration. Any differences were addressed by discussing them with a third reviewer (BL).

Quality assessment. A total of two separate reviewers (GF and BL) performed quality assessments using the checklist for analytical cross-sectional studies from the Critical Appraisal tools for use in JBI Systematic Reviews (quality assessment tool) (11). The risk of bias figures were generated using the Robvis ROB1 (visualization platform) dataset tool in R software (version 4.2.1) (12).

Statistical analysis. The data were analyzed using R software. The relationship between LE8 and MASLD was evaluated by synthesizing a pooled OR with a 95% CI. Heterogeneity was assessed using Cochrane's Q test, and the I^2 statistic was used to quantify its magnitude. The Cochrane's risk of bias assessment was used for quality evaluation. An I^2-value of 25, 50 or 75% indicated low, moderate or high heterogeneity, respectively. In instances of low or moderate heterogeneity, a common-effects (fixed-effects) model was employed. Furthermore, a random-effects model was employed for the synthesis of results from included studies in cases of significant heterogeneity. Sensitivity analyses by excluding one study were conducted to address the issue of heterogeneity. Furthermore, publication bias was assessed using funnel plots (trim and fill analysis). If a single study was the sole contribution to the analysis, the forest plot was not displayed. The subgroup analysis and meta-regression could not be meaningfully performed because only five studies were included, and the available study-level data were limited. A statistically significant result was defined as one with $P<0.05$.

Results

Included studies. During the initial search, a total of 97 potential references were found. After removing duplicate articles, 38 relevant references were screened. Based on the titles and abstracts, 20 records were excluded from further consideration. Of the remaining 18 publications, 4 were review articles, 5 had unrelated outcomes and 4 studies were excluded due to insufficient data. Ultimately, 5 eligible studies were included in the present meta-analysis. The study's flowchart is provided in Fig. 1.

The baseline characteristics of the studies included in the analysis are presented in Table I (13-17). As individual-level confounder data could not be extracted from the included studies, further investigation is warranted to corroborate these meta-analytic findings. The study encompassed 36,187 participants aged 18 to 70 years. All of the studies were high quality and met the Cochrane criteria for parallel group research (10).

Bias risk analysis. A comprehensive overview of the potential biases is presented in Fig. S1. Overall, the included studies were deemed to be without high risk of bias. The studies were carried out with patients who were free of disease. The summary figure shows the risk-of-bias assessment for each included study and the risk-of-bias graph summarizes the overall judgments across all studies (Fig. S1A and B).

Association of moderate (M)LE8 score with MASLD risk. The five included studies involved a total of 36,187 participants, reporting the potential risk of an MLE8 score in association with the risk of MASLD. The pooled results illustrated that an MLE8 score was associated with a reduced risk of MASLD compared to a low (L)LE8 score (OR=0.36, 95% CI: 0.25-0.52) (Fig. 2).

Association of high (H)LE8 score with MASLD risk. The five included studies documented the potential risk associated with HLE8 scores in relation to the likelihood of developing MASLD. The pooled results revealed that compared to LLE8 score, HLE8 score were associated with a lower risk of MASLD (OR=0.07, 95% CI: 0.02-0.19) in the general population (Fig. 3). Due to the heterogeneity observed during the pooled analysis of the HLE8 score in comparison with the LLE8 score in relation to MASLD risk, the data were synthesized using a random-effects model.

Heterogeneity and publication bias. A statistical heterogeneity was noted in the overall results of the LE8 score and MASLD risk in comparison with the LLE8 score (I^2=97.9%).

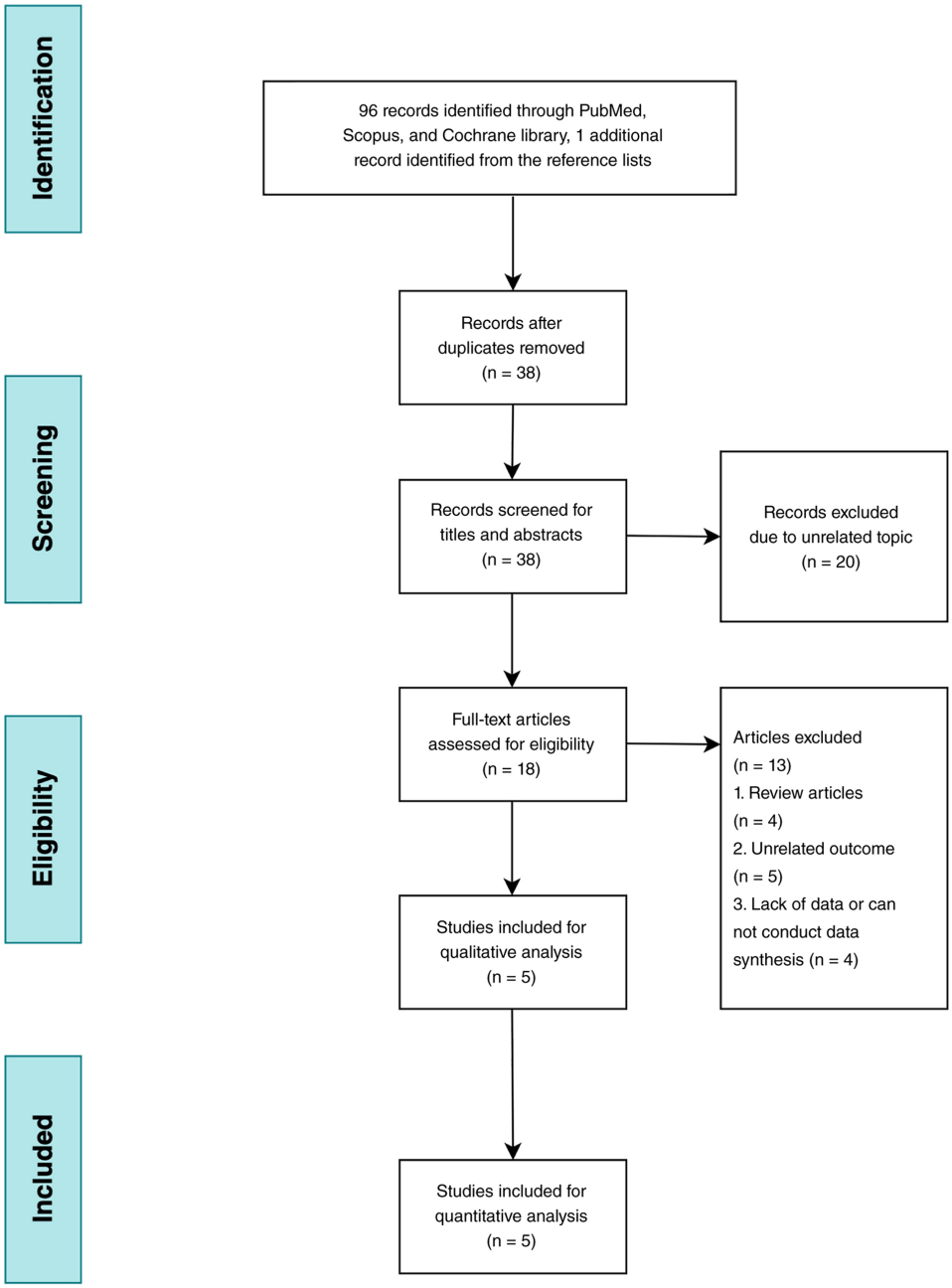

Figure 1. Flow diagram of the literature search.

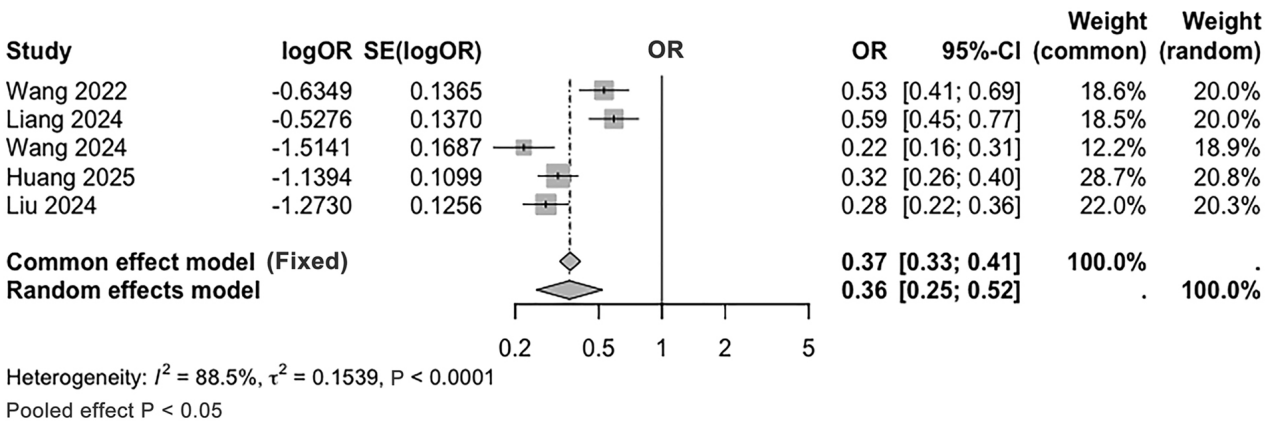

Figure 2. Forest plot of moderate compared to low LE8 score with MASLD risk. LE8, Life's Essential 8; MASLD, metabolic dysfunction-associated steatosis liver disease; OR, odds ratio; SE, standard error.

Table I. Characteristics of included studies in the meta-analysis.

First author, year	Journal	Study design	Participants, n	Male sex, n	Mean age, years	MASLD diagnosis	Outcomes	(Refs.)
Wang, 2024	Archives of Public Health	Population-based cross-sectional study (NHANES)	5,646	2,792	50.2	CAP	Risk of MASLD	(13)
Huang, 2025	Journal of Health, Population and Nutrition	Population-based cross-sectional study (NHANES)	5,680	2,799	≥20	CAP	Risk of MASLD	(14)
Wang, 2022	Journal of Translational Medicine	Population-based cross-sectional study (NHANES)	3,588	1,479	≥20	CAP	Risk of MASLD	(16)
Liu, 2024	Scientific Reports	Population-based cross-sectional study (NHANES)	9,453	4,536	≥18	CAP	Risk of MASLD	(15)
Liang, 2024	Frontiers in Nutrition	Population-based cross-sectional study (NHANES)	11,820	4,514	48.9	CAP	Risk of MASLD	(17)

NHANES, National Health and Nutrition Examination Survey; MASLD, metabolic dysfunction-associated steatosis liver disease; CAP, controlled attenuation parameter.

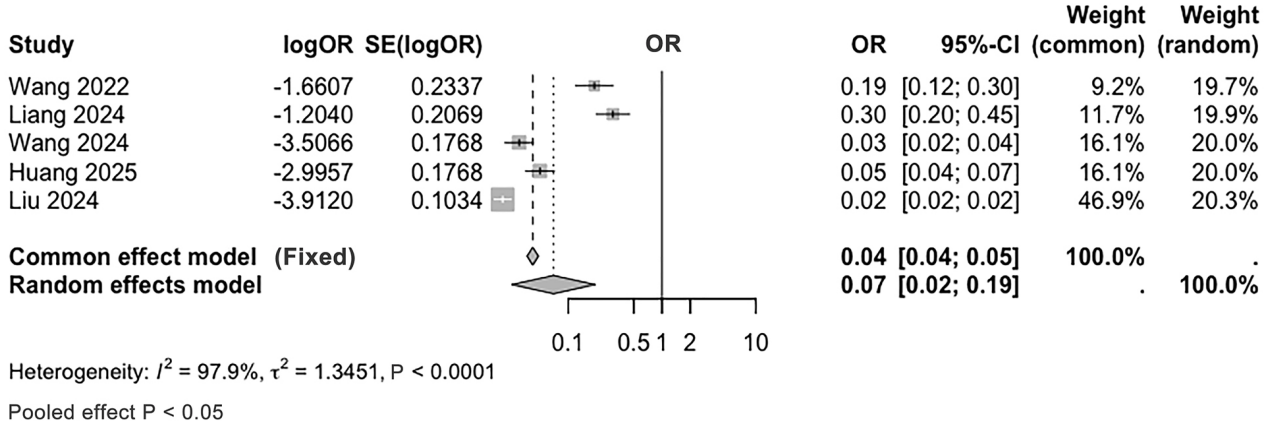

Figure 3. Forest plot of high compared to low LE8 score with MASLD risk. LE8, Life's Essential 8; MASLD, metabolic dysfunction-associated steatosis liver disease; OR, odds ratio; SE, standard error.

To identify the source of heterogeneity, a sensitivity analysis was conducted (Figs. S2 and S3). The results indicated that the association between LE8 and MASLD was relatively stable but with significant heterogeneity. Subsequently, a Trim and Fill analysis was conducted and two supplementary studies were integrated into the analysis (Figs. S4 and S5). The funnel plots were symmetrical, which suggests low publication bias. The findings indicated that the HLE8 score was also associated with a diminished risk of MASLD (OR=0.028, 95% CI: 0.0072-0.1094) (Fig. S5), thereby providing further corroboration of the stability of the primary results.

Discussion

The present meta-analysis sought to evaluate the associations between the LE8 cardiovascular health score and the risk of developing MASLD. The study incorporated five observational studies, covering a total of 36,187 participants aged 18 to 70 years. To the best of our knowledge, the present study was the first to provide a comprehensive meta-analysis and determine that a favorable lifestyle with an optimal and higher LE8 score was associated with a significantly lower risk of MASLD.

The AHA proposed LS7 as a means of measuring cardiovascular health in 2010, with the goal of further improving the general population's health (18). A significant body of evidence has confirmed that maintaining optimal cardiovascular health as defined by LS7 is linked to improved survival free from CVD, increased longevity and a higher quality of life (19-21). Previous studies have shown that an ideal LS7 may not only reduce the prevalence of MASLD but also promote its regression-particularly among individuals with

a genetic predisposition to the disease (22,23). Nevertheless, the original LS7 score was also found to have certain limitation (not including sleep quality, social determinants). Then the AHA has recently updated the assessment tool for quantifying cardiovascular health, namely by releasing the LE8 (7). The LE8 scoring system is more sensitive to inter-individual discrepancies and emphasizes the social determinants of health and psychological well-being as determinants of sustained or enhanced cardiovascular health (24). The LE8 scoring algorithm comprises eight items: Four health behaviors (dietary habits, physical activity, nicotine exposure and sleep duration) and four health factors (BMI, non-high-density lipoprotein cholesterol, blood glucose and blood pressure). According to the AHA guidelines, LE8 scores between 80 and 100 indicate high cardiovascular health, scores between 50 and 79 suggest moderate, and scores between 0 and 49 reflect low cardiovascular health. There is limited research showing the potential benefits of optimal LS7 for MASLD. The detailed LE8 provides more precise values for each measure, improving the assessment's sensitivity. In this respect, the LS7 score's categories for blood pressure, BMI, blood glucose and blood lipids may not fully reflect the elevated risk of CVD associated with deviations from the typical range of these indices (25). To date, only two meta-analyses have evaluated the relationship between LE8 and CVD risk (26,27). However, no meta-analysis has been conducted to assess the relationship between LE8 and MASLD. Therefore, in the present study, a comprehensive meta-analysis was conducted for the first time to connect the LE8 score with the risk of MASLD.

MASLD has been associated with a higher risk of developing various health conditions, including coronary heart disease (CHD), type 2 diabetes mellitus, chronic kidney disease, arrhythmia, heart failure and cancers (28-31). Therefore, it is essential to carefully identify and understand the risk factors that make a person more likely to develop MASLD. The new way of calculating the cardiovascular health score has led to significant changes in cardiovascular health status between the LS7 and LE8 scoring systems, particularly for individuals previously rated as having the best cardiovascular health using LS7 scoring. A study using the LE8 scoring system found that 47.3% of individuals previously classified to have an optimal cardiovascular health score of LS7 were reclassified as having intermediate or poor cardiovascular health according to the LE8 score (32). This reclassification affects ~19 million individuals who could benefit from preventive interventions and affects those originally classified as having ideal cardiovascular health under LS7. It identifies new ways to prevent problems in individuals previously considered to have optimal cardiovascular health. A cross-sectional study that adjusted for risk factors found that average and optimal cardiovascular health categories based on LS7 were linked to lower odds of MASLD compared to those with inadequate score, moderate LS7 decreased MASLD risk (OR=0.44, 95% CI, 0.36-0.54); compared to inadequate LS7 score, high LS7 score further reduced the MASLD risk (OR=0.19, 95% CI, 0.14-0.26) (33). A recent Korean study also calculated the cardiovascular health score under LS7 and indicated that the OR for NAFLD was lower in participants with ideal cardiovascular health (OR=0.13, 95% CI, 0.08-0.18) compared to those with poor scores (OR=2.87, 95% CI, 2.13-3.86) (34). The present results showed that an HLE8 score was linked to a lower risk of MASLD (OR=0.07, 95% CI: 0.02-0.19).

The complex and multifaceted nature of sleep, coupled with its robust correlation with other key determinants of cardiovascular health, has led to its incorporation into the LE8 score. There is a clear association between poor sleep quality and the development of obesity, hypertension, hyperlipidemia and diabetes mellitus. It's also worth mentioning that not getting enough sleep has been linked to an increased risk of developing CVD, including CHD, stroke and heart failure. The inclusion of sleep as a new component in the cardiovascular health metric represents a meaningful advancement in promoting holistic health (7). A prospective cohort study revealed that the incidence of cirrhosis in individuals with MASLD, without a history of frequent insomnia [hazard ratio (HR)=0.73, 95% CI: 0.61-0.87], but participants with MASLD and adverse sleep pattern showed a higher risk of developing cirrhosis (HR=3.16, 95% CI: 1.88-5.33) (35). A further cross-sectional study based on data from the National Health and Nutrition Examination Survey (NHANES) indicated that the presence of any sleep disorder, sleep apnea and insomnia were all independently associated with MASLD (OR=1.40, 95% CI: 1.11-1.76, OR=1.39, 95% CI: 0.98-1.97, and OR=2.17, 95% CI: 1.19-3.95, respectively) (36). Consequently, the LE8 score is more precise than the LS7 score, and thus, the evidence of LE8 and MASLD risk in the present study may provide a more tangible indication of the potential link between them.

The present findings should be interpreted in the context of several methodological limitations: i) For the inherent nature of meta-analyses, overlapping is unavoidable. ii) There was obvious heterogeneity, although stable results were gained after conducting a sensitivity analysis and performing a trim-and-fill analysis. Several factors may contribute to the observed heterogeneity, including differences in sex distribution, age range, study design and analytic methods among the included studies. Further studies are needed to confirm the results of the present study. iii) Another key limitation of the present study is the restricted geographical scope of its data sources. All included studies drew on NHANES data, which are derived exclusively from US populations and do not include participants from other regions, such as Asia or Europe. This may limit the generalizability of the findings to other populations. iv) The available evidence, largely from cross-sectional NHANES analyses, is insufficient to support causal conclusions regarding LE8 and MASLD risk. Well-designed prospective cohort studies in diverse settings are urgently needed to validate these associations and inform clinical practice. v) NAFLD and MASLD represent the same underlying disease entity, but were proposed at different times to reflect the evolving understanding of the condition. MASLD is currently the most recent and recommended nomenclature. The included studies differed in their definitions of MASLD, which may have introduced clinical heterogeneity and underscores the need for further studies to corroborate the present findings. vi) This study was not preregistered, but was conducted in accordance with established meta-analysis guideline (10).

In conclusion, the updated metrics of LE8 offer a valuable framework for crafting personalized strategies to prevent MASLD and promote overall health. It is reasonable to propose that targeted interventions, especially those addressing multiple health behaviors and risk factors (such as diet, sleep, physical activity, blood pressure and blood glucose) simultaneously, will be more effective than those focusing on individual factors in isolation. These insights emphasize the potential of the LE8 to guide the development of impactful preventive strategies and public health initiatives aimed at reducing the global burden of MASLD. However, the substantial heterogeneity observed across the included studies warrants a cautious interpretation of these findings.

Acknowledgements

Not applicable.

Funding

No funding was received.

Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

GF was involved in the conceptualization of the study, data curation, formal analysis, investigation, methodology, resources, software, supervision, validation, visualization, writing-original draft and writing-review and editing. BL was responsible for investigation, methodology, resources, software, supervision, validation and visualization. HZ contributed to data curation, formal analysis, investigation, methodology, software, validation, visualization and writing-review and editing. GF and BL checked and confirm the authenticity of all the raw data. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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