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Systematic Review Article

A Systematic Review and Meta-Analysis of the Prevalence of Non-Alcoholic Fatty Liver Disease in Iranian Children: Analysis of Body Mass Index, Sex, and Grades

Kaveh Ebadi[1], Milad Jalilian[1*]

[1] Department of Nursing, Faculty of Nursing and Midwifery, Kurdistan University of Medical Sciences, Sanandaj, Iran.

ABSTRACT

Background:
Non-alcoholic fatty liver disease (NAFLD) is one of the most common liver disorders worldwide, particularly in children. Iranian children are also at risk of developing NAFLD and its complications due to rising obesity and sedentary lifestyles. This study aimed to assess the prevalence of NAFLD among Iranian children based on body mass index (BMI) distribution, sex, and NAFLD grades through a systematic review and meta-analysis.

Materials and Methods:
The study was designed and conducted following the PRISMA guidelines for article search, validation, selection, data extraction, and reporting. English and Persian language databases were searched up to 1 January 2025. All retrieved articles were evaluated and reviewed. Meta-analysis of the results was performed using CMA software, and findings were reported following the Garrard approach.

Results:
Fifteen studies met the inclusion criteria, covering a total of 10,138 Iranian children between 2009 and 2023. The meta-analysis revealed that the overall prevalence of NAFLD in Iranian children was 23.3%. The prevalence based on BMI was 3.9% for children with NAFLD than girls (35.1% versus 22.4%). The study also showed that 18.3% of children had grade I NAFLD, while 3.8% were diagnosed with grade II.

Conclusion:
Fatty liver disease is prevalent among children and is nearly as common as in adults. Diet and reduced physical activity are major risk factors for NAFLD, making their management crucial for preventing and treating the condition.

Keywords: Fatty liver disease, NAFLD, MASLD, Children, BMI, Sex, Grades, Prevalence, Iranian

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**Corresponding Author:*
Milad Jalilian, MSc of Medical-Surgical Nursing
Department of Nursing, Faculty of Nursing and
Midwifery, Kurdistan University of Medical Sciences,
Sanandaj, Iran.
Tel: + 98 9187931047
Email: milladj1994@gmail.com

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INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) is recognized as one of the leading causes of chronic liver disease worldwide (1, 2). Although the term non-alcoholic fatty liver disease (NAFLD) has recently been revised to metabolic dysfunction-associated steatotic liver disease (MASLD) (3), due to greater familiarity among readers and the terminology used in the referenced studies, we predominantly use the term NAFLD in this study. NAFLD is defined as the accumulation of over 5% fat in the liver tissue in the absence of other causes, such as alcohol consumption, viral or autoimmune conditions, endocrine disorders, or the use of liver-toxic medications (4). NAFLD refers to a range of conditions, from simple steatosis to progressive non-alcoholic steatohepatitis (NASH), liver fibrosis, and advanced cirrhosis (5, 6).

Globally, the prevalence of NAFLD is estimated to be around 15-30%, with variations depending on the region due to differences in lifestyles (7, 8). In non-obese individuals across Asia and the Pacific, rates range from 15% to 21%, while in American adults, it is around 30%, and in Italy, 25% (9, 10). Asia has the highest prevalence of NAFLD worldwide, with approximately 20% of children and adults affected (10). The Middle East also shows a higher prevalence, with rates in Iran estimated between 30% and 40% (11, 12).

NAFLD is not just limited to adults. It is increasingly common among children. It is currently considered the most significant liver disease in children globally, with prevalence rates estimated between 5% and 70%, depending on the population, and is rising rapidly (6, 13, 14). Lifestyle changes, physical inactivity, high-fat diet, and obesity are the primary drivers of fatty liver disease in children (15-18). It is predicted that the prevalence of NAFLD will increase in the adult and pediatric population as obesity continues to increase (2). In Iranian children, the prevalence of NAFLD has been reported to range from 1.5% to 59% (19, 20).

Fatty liver disease was first identified by Ludwig and colleagues in 1980, and cases in children were reported by 1983 (21, 22). Obesity, low physical activity, and insulin resistance are known to increase the risk of NAFLD, but the exact process behind the disease is still unclear (10, 18). Pediatric NAFLD is a tough challenge for doctors and healthcare professionals because it is caused by a mix of genetic, environmental, and other factors, such as sedentary lifestyle and diet (6). Over the last 30 years, NAFLD has become more common in children as obesity rates have risen. Lifestyle and economic changes in developing countries like Iran have also led to a noticeable increase in childhood obesity (23).

Childhood obesity is now a global issue and a major cause of NAFLD, which can result in serious health and behavior problems (14, 18, 24). Fatty liver is linked to higher death rates and is a warning sign for future heart disease (25). It is also tied to conditions like diabetes, poor nutrition, and obesity, increasing the risks of liver damage and heart problems (26). Fatty liver disease is one of the main reasons for liver transplantations (27, 28). Elevated liver enzyme levels in children are seen as a heart risk and a part of metabolic syndrome (29).

Given the growing number of cases of NAFLD in Iranian children and the limited research in Iran, this study focuses on exploring the prevalence of NAFLD among overweight and obese children.

MATERIALS AND METHODS

2.1 Study Protocol

This research was conducted as a systematic review and meta-analysis following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guideline (30). The study aimed to report the prevalence of fatty liver disease in Iranian children overall and by body mass index (BMI), sex, and disease grade. The systematic review and meta-analysis protocol was approved and registered by the Research Ethics Committee at Kermanshah University of Medical Sciences (Approval Code: IR.KUMS.REC.1401.289).

2.2 Search Strategy

The study followed the PRISMA framework for searching, selecting articles, extracting data, reporting findings, and writing systematic review and meta-analysis articles. A comprehensive search of Persian and English databases was conducted up to 1 January 2025, covering both international and Iranian sources. The databases included Web of Science, PubMed, Scopus, Google Scholar, and Persian databases such as SID, IranDoc, and IDML.

Keywords were standardized based on PubMed MeSH terms and included terms such as:

Fatty Liver Disease, Fatty Liver Disorder, Metabolic Dysfunction-associated Steatotic Liver Disease, MASLD, Steatotic Liver Disease, FLD, NAFLD, Metabolic Dysfunction-Associated Fatty Liver Disease, MAFLD, Iran, Iranian, Children, Kid, Teenagers, Prevalence, Grade, Stage, and their Persian equivalents.

These terms were searched separately and in combination. Keywords selected based on the study's title, objectives, and prior research. Additionally, references from selected articles were screened to identify other relevant studies.

Although the terminology for NAFLD was recently updated to MASLD, we used the term NAFLD throughout this study to ensure consistency with the original terminology

used in all included articles.

2.3 Inclusion and Exclusion Criteria

All articles available up to 1 January 2025 were reviewed. Observational studies with original results were included if they provided sufficient information on the overall prevalence of fatty liver or its relationship with BMI, sex, and disease grade. Non-observational studies (e.g., reviews, meta-analyses, letters to the editor, case reports, comments) were excluded, as were studies with results unrelated to the research objectives.

The present review focuses on studies conducted in children. Therefore, we included only articles in which the authors explicitly stated that the study population consisted of Iranian children. Based on the included studies, the age range covered was between 6 months and 18 years.

2.4 Article Selection and Validation

All found titles were imported into EndNote V.20 to identify and remove duplicates. The remaining titles and abstracts were independently reviewed by two authors (MJ, KE) to select studies based on design and initial information. The full texts of these articles were then carefully reviewed multiple times by the same authors to extract the necessary data for the research objectives. Data extraction was done through detailed and repeated reading of the articles, and the information was summarised in tables. Any disagreements during the selection and data extraction process were resolved through group discussions.

2.5 Quality Assessment

The quality of selected articles was evaluated using an adapted version of the Newcastle-Ottawa Scale for assessing the cross-sectional studies in meta-analysis (31-33). This scale assesses studies based on design, recruitment strategy, response rate, sample representativeness, reliability of outcome determination, power calculation, and statistical analyses. Quality evaluation was performed independently by two researchers (MJ, KE). Any disagreements were resolved through group discussion.

2.6 Meta-Analysis and Publication Bias

Eight meta-analyses were conducted using CMA (Comprehensive Meta-Analysis) software. These analyses covered the overall prevalence of fatty liver in Iranian children, its relationship with BMI status, sex, and different disease grades. We anticipated potential heterogeneity among included studies and therefore planned to use a random-effects model for data analysis. Heterogeneity was assessed using the I^2 statistic. Publication bias was assessed using Egger's regression intercept test.

2.7 Data Analysis and Reporting

Data were analyzed through careful review and reported using the Garrard method, which provides guidance for systematic reviews and meta-analyses (34). The reported data included study design, publication year, province or city, participants, sex, disease grades, BMI information, prevalence rates, and study quality. In studies that reported multiple data, all relevant information was included.

RESULTS

3.1 Selection of Eligible Articles

In the initial database search up to January 1, 2025, 410 articles with titles related to the study were identified. The list of titles was imported into EndNote V.20 software, and after removing duplicates, 303 titles remained. The titles and abstracts of these articles were reviewed independently by two authors (MJ, KE). After excluding irrelevant articles, 27 were selected for more detailed assessment. Full texts and tables were carefully reviewed, and 15 articles were included in the study (Figure 1).

All 15 articles provided sufficient information to be included in the meta-analysis, enabling the assessment of the overall prevalence of fatty liver in children. All included articles were of moderate to high quality, as assessed by the quality assessment tool used. Given the type of analysis conducted and the consistent findings, study quality did not influence the pooled estimates. For evaluating the prevalence based on BMI categories (normal BMI, overweight, and obesity), 4, 6, and 9 articles, respectively, were included. Additionally, eight articles had adequate data for sex-based prevalence analysis (Figure 1). The BMI categories used in this review were based on the classifications reported in the included studies. Although the original articles did not consistently specify the exact criteria for BMI categorization, it is generally assumed that standard definitions based on BMI-for-age z-scores or percentile cut-offs were applied. The referenced studies reported which BMI category the study participants belonged to.

3.2 Meta-Analysis

Due to the high heterogeneity among the included studies (Table 1), a random-effects model was used to synthesize the results.

3.3 Characteristics of the Studies

All articles used a cross-sectional design, and fatty liver was confirmed by ultrasound. The studies were conducted in Iran between 2009 and 2023, and most research focused on Tehran and Isfahan provinces. Central provinces had the highest number of studies, while no studies were conducted in western Iran.

A total of 10,138 children were included, with numbers ranging from 60 to 2,526. Children were classified by BMI as follows: 179 were underweight (lean), 1,945 had a normal BMI, 1,608 were overweight, and 1,786 were

obese. Data on BMI were incomplete for 4,620 children across five studies. Participants were aged between 6 months and 18 years. Sex distribution included 3,894 girls and 3,577 boys, although three articles did not provide complete information about participants' sex (Table 2). Only four studies reported age-related prevalence, and their age groupings were not consistent.

3.4 Overall Prevalence of Fatty Liver in Iranian Children

15 studies were included to analyze the prevalence of fatty liver in children, with reported rates ranging from 1.5% to 59% (Table 2). Given the high level of heterogeneity (I^2 > 98%), the pooled prevalence estimates should be interpreted with caution. Meta-analysis results showed an overall prevalence of 23.3% with 95% confidence intervals (13.9% - 36.4%) (Figure 2). No publication bias was detected (t-value=0.57, P value=0.286).

3.5 Prevalence of Fatty Liver by BMI

• **Underweight Children:** Reported in only one study, with a prevalence of 3.3% (Table 3).

• **Normal BMI:** Reported in four studies, with prevalence ranging from 0.7% to 16.7% (Table 3). Meta-analysis indicated an average prevalence of 3.9% (95% CI 0.6%-21%) (Figure 3-A), (no publication bias: t-value=0.233, P value=0.418)

• **Overweight Children:** Reported in six studies, with prevalence from 1.3% to 54.2% (Table 3). Meta-analysis showed an average prevalence of 14.4% (95% CI 5.7%-32.1%) (Figure 3-B), with no publication bias (t-value=0.88, P value=0.466).

• **Obese Children:** Reported in nine studies, with prevalence ranging from 4% to 83.7% (Table 3). Meta-analysis revealed a prevalence of 44.1% (95% CI 27.2%-62.6%) (Figure 3-C). No publication bias was detected (t-value=0.058, P value=0.477).

3.6 Prevalence by Sex

Eight studies reported prevalence by sex, showing rates from 1% to 50% in girls and 1.8% to 69.8% in boys (Table 4). The results showed a higher prevalence in boys than in girls, confirmed by meta-analysis results showing 22.4% in girls (95% CI 10.9%-40.6%) and 35.1% in boys (95% CI 15.4%-61.7%) (Figure 4). No publication bias was seen (girls: t-value=0.1158, P value=0.455; boys: t-value=0.9308, P value=0.193).

3.7 Prevalence by Disease Grade

Grades I and II were more common than other levels of fatty liver (Table 5). The meta-analysis of 10 articles showed a Grade I prevalence of 18.3% (range 1.1% to 51% - 95% CI 7.4%-38.5%) and a Grade II prevalence of 3.8% (range 0.16% to 12% - 95% CI 3.2%-4.5%) (Figure 5). Grade III was reported in four studies, ranging from 0.03% to 1% (Table 5).

Table 1. Heterogeneity of Included Studies

Groups	P value	I^2
Overall prevalence	P < 0.001	98.95
Prevalence in Normal BMI	P < 0.001	96.14
Prevalence in overweight children	P < 0.001	96.46
Prevalence in obese children	P < 0.001	97.12
Prevalence in girls	P < 0.001	97.81
Prevalence in boys	P < 0.001	98.69
Prevalence in Grade 1	P < 0.001	99.13
Prevalence in Grade 2	P < 0.001	93.75

Table 2. Characteristics of Included Studies

Study	Design	Pub date - city	Participants	Sex	Total prevalence (%)	Quality score
Adibi et al. (35)	CS	2009 - Isfahan	952 (6-18 y) Mod: 408 Ow: 314 Ob: 230	537 G 415 B	161 (16.9)	9
Rafeey et al. (36)	CS	2009 - Tabriz	1500 (6 months – 15 years)	-	34 (2.3)	6
Alavian et al. (37)	CS	2009 - Tehran	966 Mod / Ow / Ob (7 – 18 y)	533 G 433 B	69 (7.1)	9
Tazhibi et al. (38)	CS	2010 - Isfahan	1107 (6 – 18 y)	-	187 (16.9)	8
Hosseini et al.	CS	2011 - Isfahan	931 Mod / Ow / Ob (6 – 18 y)	518 G 413 B	156 (16.8)	8

Table 2. Characteristics of Included Studies

Study	Design	Pub date - city	Participants	Sex	Total prevalence (%)	Quality score
Arani et al. (39)	CS	2013 - Kashan	306 (4-18 y) All Obese	178 G 128 B	163 (53.3)	7
Saki et al. (40)	CS	2014 - Shiraz	102 (5-17 y) All Obese	66 G 36 B	56 (54.9)	8
Taghavi Ardakani et al. (20)	CS	2015 - Kashan	200 (5-15 y) All Obese	78 G 122 B	118 (59)	7
Tavakoli et al. (41)	CS	2017 - Golestan	90 (5-13 y) Mod: 30 Ow: 30 Ob: 30	51 G 39 B	17 (18.88)	6
Kazemi e al. (26)	CS	2017 - Zanjan	240 (12-18 y) Mod: 95 (39.6) Ow: 59 (24.6) Ob: 86 (35.8)	120 G 120 B	119 (49.58)	8
Namakin et al. (14)	CS	2018 - South Khorasan	200 (12-18 y) Ow: 90 Ob: 110	114 G 86 B	108 (54)	10
Gheibi et al. (23)	CS	2019 - Uremia	843 (2-19 y) Ow: 506 Ob: 337	418 G 425 B	93 (11)	10
Sadeghian et al. (19)	CS	2022 - Tehran	2526 Mod: 1412 Ob: 325 Ow: 609 Lean: 179	1237 G 1289 B	37 (1.5)	10
Shahraki et al. (42)	CS	2022 - Zahedan	60 (5-17 y) All Obese	-	34 (57)	7
Imanzadeh et al. (43)	CS	2023 - Tehran	115 (7-17 y)	44 G 71 B	55 (47.8)	7

CS: Cross-sectional; Mod: Normal BMI; Ob: Obese; Ow: Overweight; G: Girls; B: Boys

Table 3. Prevalence of NAFLD in Normal BMI, Overweight, and Obese Children

Studies	Participants	NAFLD Prevalence (%)
Saki et al. (40)	Ob: 102 Ow: -	Ob: 56 (54.9)
Taghavi Ardakani et al. (20)	Ob: 200 Ow: -	Ob: 118 (59)
Gheibi et al. (23)	Ow: 506 Ob: 337	Ow: - (9.5%) Ob: - (21.4%)
Namakin et al. (14)	Ow: 90 Ob: 110	Ow: 32 (35.6) Ob: 76 (69.1)
Kazemi e al. (26)	Nor: 95 Ow: 59 Ob: 86	Nor: 15 (15.8) Ow: 32 (54.2) Ob: 72 (83.7)
Adibi et al. (35)	Nor: 408 Ow: 314 Ob: 230	Nor: 4 (1) Ow: 33 (10.5) Ob: 124 (54)
Tavakoli et al. (41)	Nor: 30 Ow: 30 Ob: 30	Nor: 5 (16.7) Ow: 5 (16.7) Ob: 7 (23.3)
Shahraki et al. (42)	Ob: 60 Ow: -	Ob: 34 (57)
Sadeghian et al. (19)	Nor: 1412 Ob: 325 Ow: 609 Lean: 179	Nor: 10 (0.7) Ob: 13 (4) Ow: 8 (1.3) Lean: 6 (3.3)

Nor: Normal BMI; Ob: Obese; Ow: Overweight

Table 4. Prevalence of NAFLD in Girls and Boys

Study	Participants by sex	NAFLD prevalence by sex (%)
Adibi et al. (35)	Girls: 537 Boys: 415	Girls: 80 (15) Boys: 81 (19.5)
Arani et al. (39)	Girls: 178 Boys: 128	Girls: 84 (47.2) Boys: 79 (61.7)
Taghavi Ardakani et al. (20)	Girls: 78 Boys: 122	Girls: 39 (50) Boys: 79 (64.7)
Kazemi e al. (26)	Girls: 120 Boys: 120	Girls: 48 (40) Boys: 71 (59.2)
Namakin et al. (14)	Girls: 114 Boys: 86	Girls: 48 (42.1) Boys: 60 (69.8)
Gheibi et al. (23)	Girls: 418 Boys: 425	Girls: 43 (10.3) Boys: 50 (11.8)
Sadeghian et al. (19)	Girls: 1237 Boys: 1289	Girls: 13 (1.05) Boys: 24 (1.8)
Imanzadeh et al. (43)	Girls: 44 Boys: 71	Girls: 15 (34.1) Boys: 40 (56.3)

Table 5. Prevalence of Fatty Liver Grades in All Participants

Studies	Participants	Grades prevalence (%)
Arani et al. (39)	306	G I: 156 (51) G II: 7 (2.3)
Saki et al. (40)	102	G I: 44 (43.1) G II: 12 (11.8)
Taghavi Ardakani et al. (20)	200	G I: 108 (54) G II: 10 (5)
Gheibi et al. (23)	843	G I: 65 (7.71) G II: 28 (3.32)
Namakin et al. (14)	200	G I: 90 (45) G II: 16 (8) G III: 2 (1)
Kazemi e al. (26)	240	G I: 97 (40.4) G II: 22 (9.2)
Alavian et al. (37)	966	G I: 58 (6) G II: 10 (1.03) G III: 1 (0.1)
Rafeey et al. (36)	1500	G I: 18 (1.2) G II: 13 (0.86) G III: 3 (0.2)
Shahraki et al. (42)	60	G I: 27 (45) G II: 7 (12)
Sadeghian et al. (19)	2526	G I: 28 (1.1) G II: 4 (0.16) G III: 1 (0.03) Focal fatty Change: 4 (0.16)

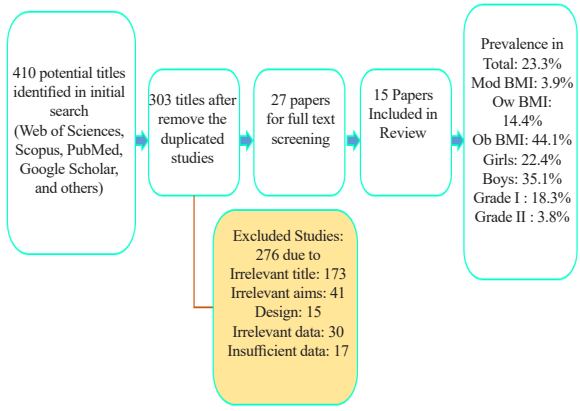


Figure 1. Graphical Abstract of Study Selection and Results

Figure 2. Total Prevalence on Fatty Liver in Iranian Children

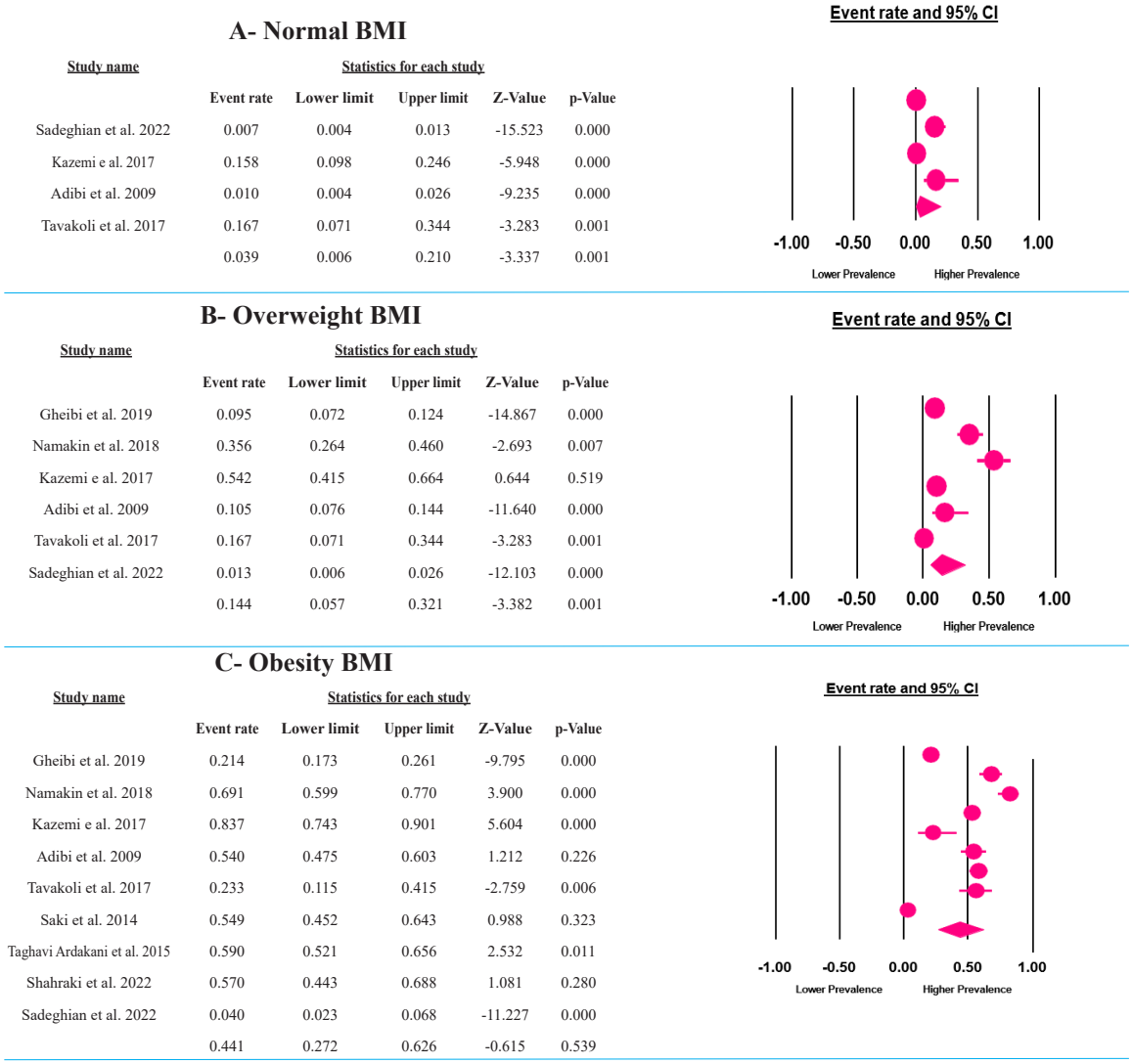
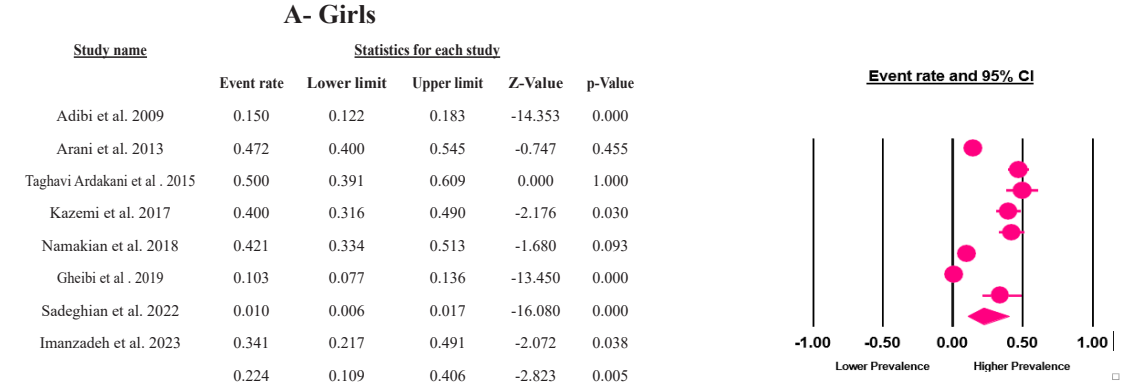
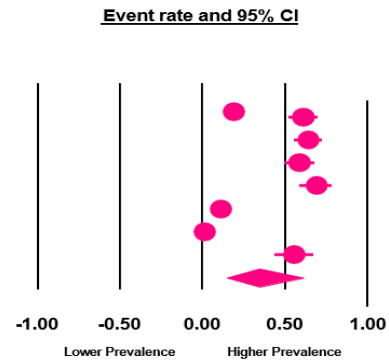


Figure 3. Prevalence of Fatty Liver Based on the BMI: (A) Normal BMI, (B) Overweight, (C) Obese



B- Boys

Study name	Event rate	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study				
Adibi et al. 2009	0.195	0.160	0.236	-11.444	0.000
Arani et al. 2013	0.617	0.530	0.697	2.622	0.009
Taghavi Ardakani et al . 2015	0.647	0.558	0.727	3.198	0.001
Kazemi et al. 2017	0.592	0.502	0.676	2.004	0.045
Namakian et al. 2018	0.698	0.593	0.786	3.567	0.000
Gheibi et al . 2019	0.118	0.091	0.152	-13.378	0.000
Sadeghian et al. 2022	0.018	0.012	0.027	-19.089	0.000
Imanzadeh et al. 2023	0.563	0.446	0.673	1.059	0.290
	0.351	0.154	0.617	-1.100	0.271

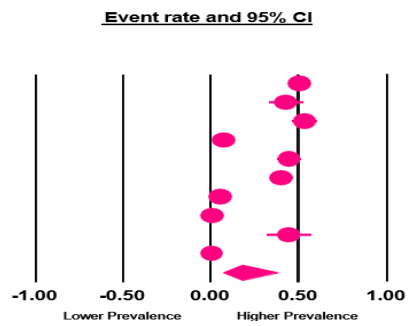


Meta Analysis

Figure 4. Prevalence of Fatty Liver in (A) Girls and (B) Boys

A- Grade I

Study name	Event rate	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study				
Arani et al. 2013	0.510	0.454	0.566	0.350	0.726
Saki et al. 2014	0.431	0.339	0.528	-1.389	0.165
Taghavi Ardakani et al. 2015	0.540	0.471	0.608	1.130	0.258
Gheibi et al. 2019	0.077	0.061	0.097	-19.226	0.000
Namakin et al. 2018	0.450	0.382	0.519	-1.412	0.158
Kazemi e al. 2017	0.404	0.344	0.467	-2.956	0.003
Alavian et al. 2009	0.060	0.047	0.077	-20.310	0.000
Rafeey et al. 2009	0.012	0.008	0.019	-18.601	0.000
Shahraki et al. 2022	0.450	0.330	0.576	-0.773	0.439
Sadeghian et al. 2022	0.011	0.008	0.016	-23.583	0.000
	0.183	0.074	0.385	-2.857	0.004



B- Grade II

Study name	Event rate	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study				
Arani et al. 2013	0.023	0.011	0.047	-9.831	0.000
Saki et al. 2014	0.118	0.068	0.196	-6.554	0.000
Taghavi Ardakani et al. 2015	0.050	0.027	0.090	-9.075	0.000
Gheibi et al. 2019	0.033	0.023	0.047	-17.519	0.000
Namakin et al. 2018	0.080	0.050	0.127	-9.370	0.000
Kazemi e al. 2017	0.092	0.061	0.136	-10.251	0.000
Alavian et al. 2009	0.010	0.006	0.019	-14.326	0.000
Rafeey et al. 2009	0.009	0.005	0.015	-16.977	0.000
Shahraki et al. 2022	0.120	0.059	0.229	-5.015	0.000
Sadeghian et al. 2022	0.002	0.001	0.004	-12.929	0.000
	0.038	0.032	0.045	-35.546	0.000

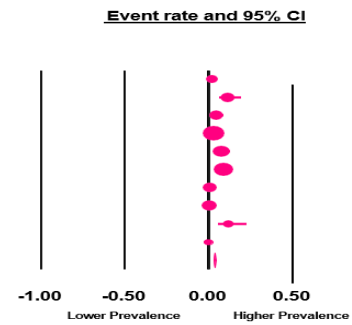


Figure 5. Prevalence of (A) Grade I and (B) Grade II of Fatty Liver Disease

DISCUSSION

The aim of this study was to calculate the prevalence of fatty liver disease among Iranian children, considering BMI, sex, and NAFLD grades. Given the high level of heterogeneity ($I^2 > 98\%$), the pooled prevalence estimates should be interpreted with caution. As reported by Lee and colleagues, the lack of standardized diagnostic and screening criteria in pediatric NAFLD may contribute to the observed heterogeneity (8). Results showed an overall NAFLD prevalence of 23.3% in Iranian children. In 2024, the prevalence of NAFLD in the general population of Iran, including both children and adults, was estimated at 33%, indicating that adding adult cases significantly increases the prevalence (12). Similar findings in this study revealed that prevalence rates will rise as participants age, which aligns with findings from other studies (44). A study of worldwide

estimation of pediatric NAFLD showed the prevalence of pediatric NAFLD was 13% in the general population and 47% in the obese population (8).

Globally, NAFLD is most prevalent in the Middle East (32%) and least common in Africa (14%) (1). Among Iranian children, earlier studies have estimated prevalence rates ranging from 6.7% to 24% (11, 45), although smaller sample sizes in some studies may have led to less accurate assessments. In other populations, NAFLD prevalence among children varies widely, with reported rates of 6.5% in North America, 7.5% in Europe, 7.6% in Africa, 25.1% in South America, and as high as 62.3% in Asia. This study also showed higher prevalence in boys compared with girls, both in the general population and among children attending obesity clinics, with rates increasing in line with BMI in both groups(46). These differences could be related to economic conditions in developing countries. Our findings demonstrated a considerable rise in NAFLD prevalence with higher BMI among Iranian children, from 3.9% in children with normal BMI to 44.1% in overweight children. The prevalence was also higher in boys (35.1%) compared with girls (22.4%), a trend seen in other studies as well (47). This pattern suggests that males, overall, are more susceptible to NAFLD than females, a disparity observed in both adults (men: 40%, women: 26%) and children (14, 26, 43, 48).Biological differences between males and females, including chromosomal structures and hormone levels, may contribute to these variations, independent of social and cultural influences on lifestyle, which also play a significant role in the development of this complex disorder (47, 49). Differences in body fat distribution between sexes also appear to influence NAFLD prevalence (50).

Cultural dietary habits are another factor contributing to differences in prevalence among populations. Studies focusing on the diets of patients with NAFLD have identified high intake of nutrient-poor foods, high-sodium and high-fat diets, particularly those rich in saturated fats and low in fresh fruits, as risk factors (51, 52). Evidence suggests that patients with NAFLD often live in areas with abundant fast-food outlets and consume unhealthy, processed foods with high salt, fat, and sugar content (53). Additionally, individuals with NAFLD tend to engage in lower levels of physical activity and spend more time sitting compared with healthy individuals (1). Other studies have linked high fructose consumption and low fiber intake to increased NAFLD risk, with children consuming more of these foods than adults (33% vs. 29.6%) (54, 55). On average, children consume up to 300 kilocalories daily from sugary drinks containing fructose (56).

Based on these findings, the most effective way to prevent and manage NAFLD is through lifestyle modifications. Given the influence of diet and obesity on NAFLD, weight management and dietary adjustments appear to be the most effective treatments. A weight reduction of 7–10% through physical activity or dietary changes can help reverse NAFLD. However, extreme weight loss from very low-carbohydrate diets can worsen NAFLD and insulin resistance (57, 58).

The Mediterranean diet, which is low in saturated fats and animal protein but rich in antioxidants, fiber, omega-3, and omega-6, is recognized as a healthy model. It reduces metabolic syndrome and cardiovascular disease (CVD). While it shows promise for treating NAFLD, more research is needed to confirm its effectiveness (59, 60).

4.1 Limitations and Recommendations

The researchers intended to conduct a separate meta-analysis based on different age groups. However, age-based categorization of children was available in only a few studies, and even among those, no consistent grouping criteria were observed. It is recommended that future studies take children's ages into account and categorize participants into different age groups based on international standards.

CONCLUSION

This study aimed to examine the prevalence of NAFLD among Iranian children based on BMI, sex, and NAFLD grades. The overall prevalence of fatty liver disease was 23.3%. Within BMI subgroups, the prevalence was 3.9% in children with average BMI, 14.4% in those who were overweight, and 44.1% in obese children. Additionally, the prevalence of NAFLD was reported to be 22.4% in girls and 35.1% in boys. Most children were diagnosed with grade I NAFLD, followed by grade II (18.3% compared with 3.1%). Researchers confirmed the impact of lifestyle factors, particularly high-sodium and high-fat diets, along with reduced physical activity, on the development of fatty liver disease. Therefore, the most crucial aspects of prevention and treatment in children involve dietary changes and increased physical activity.

ETHICS APPROVAL

The protocol of this study was approved and registered by the Research Ethics Committee at Kermanshah University of Medical Sciences (Approval Code: IR.KUMS.REC.1401.289).

AVAILABILITY OF DATA AND MATERIALS

The data from this study are available upon legitimate requests.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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AUTHORS' CONTRIBUTIONS

MJ and KE conceived the idea and designed the study concept. MJ and KE collaborated in data collection, result extraction, and data analysis. The final manuscript was written, reviewed, and revised by MJ and KE, and it has been approved by both authors.

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