Original Article

Aerobic Exercise as a Therapeutic Strategy in Children and Adolescents with Metabolic Dysfunction Associated Steatotic Liver Disease (MASLD) and Obesity: A Systematic Review

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Abstract:

Background: Metabolic dysfunction-associated Steatotic Liver Disease (MASLD) is the most prevalent chronic liver disease in children and adolescents, particularly those with obesity. MASLD often progresses to serious hepatic and metabolic complications. Although aerobic exercise (AE) is widely recommended as a first-line lifestyle intervention, its therapeutic efficacy remains unclear. This study evaluates the effects of AE on body composition, liver enzyme, lipid profile, metabolic markers, and liver imaging.

Methods: A comprehensive literature search was conducted across PubMed, Cochrane Library, Scopus, and EBSCOhost. Clinical studies involving AE in pediatric patients (≤18 years) with MASLD and BMI ≥ 85th percentile were independently screened.

Result: From 141 records, five studies (3 RCT, 2 Interventional Study) involving 97 children (mean age 13.22±2.24 years) met the inclusion criteria. AE protocols typically consisted of 30-60 minutes sessions, thrice weekly, over 1-12 months. AE intervention had significantly decreased BMI in 2 of 3 studies, and visceral fat in 1 of 2, with no change in lean mass. Significant improvements of AST and ALT (Δ –1.0 to –34.0 and –1.0 to –27.17) were reported in 3 of 5 studies. However, lipid profiles showed inconsistent effects, and most metabolic markers (glucose, insulin, HOMA-IR, adiponectin, leptin) showed no significant changes. Liver imaging from 3 studies reported resolution or reduced MASLD severity.

Conclusion: AE provides selective benefits in MASLD-obese children and adolescents. Improvements were observed in BMI, liver enzymes, and liver imaging, while the effects on lipid and metabolic markers remain inconsistent.

Keyword: aerobic exercise, liver biomarker, liver imaging, masld, obesity

Introduction

Metabolic dysfunction-associated steatotic liver disease (MASLD) has emerged as a significant health concern among children and adolescents, particularly in the context of rising obesity rates.[1] The nomenclature for this condition has evolved considerably over recent years. Initially, the term non-alcoholic fatty liver disease (NAFLD) was widely adopted to describe hepatic steatosis in the absence of significant alcohol consumption. However, in 2020, the scientific community shifted to the term metabolic dysfunction-associated fatty liver disease (MAFLD), which better reflects the underlying metabolic factors contributing to the condition.[2] This evolution continued in 2023 with the introduction of the term metabolic dysfunction-associated steatotic liver disease (MASLD).[3] MASLD is characterized by the pathological accumulation of fat in the liver, which can subsequently progress to inflammation, fibrosis, and ultimately liver failure if left untreated.[4]

The prevalence of pediatric MASLD demonstrates considerable variation across different studies, influenced by factors such as geographic location, study population characteristics, and diagnostic methodologies. A comprehensive meta-analysis conducted from 1997-2023 demonstrated that the prevalence of MASLD in children was 13% in the general population and 47% in obese children, with a notably higher prevalence observed among males. Geographic variations are particularly striking, with the prevalence of MASDL being highest in studies conducted in the Asian region, affecting 15% of the general pediatric population and 53% of obese children.[5] Another study revealed the prevalence of MASDL in the pediatric population to be 7.4% in the general pediatric population and up to 52.5% in obese children, with the highest rates documented in North America (8.53%), followed by Asia (7.01%), and the lowest prevalence in Europe (1.65%).[6]

The etiology of pediatric MASLD appears to differ from adult presentations, with maternal and perinatal risk factors potentially exerting greater influence on MASLD development compared to environmental factors.[7] The strong correlation between MASLD prevalence and increased body mass index (BMI) underscores the critical role of metabolic dysfunction in disease pathogenesis.[8] The natural history of pediatric MASLD reveals a highly variable clinical course with outcomes ranging from spontaneous resolution to life-threatening complications. Among children with MASLD who have undergone liver biopsy, 16% demonstrated significant fibrosis and 0-1% had developed cirrhosis.[9, 10] Long-term follow-up studies demonstrate that while some children experience improvement in hepatic steatosis and fibrosis with standard lifestyle interventions, others progress to advanced liver disease requiring transplantation or resulting in mortality.[11]

Current clinical guidelines recommend lifestyle modifications as the primary treatment for MASLD, with aerobic exercise (AE) widely advocated as a first-line intervention. However, despite its widespread recommendation, the therapeutic efficacy of aerobic exercise in pediatric MASLD remains unclear. This systematic review aims to evaluate the effectiveness of aerobic exercise interventions in pediatric MASDL and provide clarity on its therapeutic potential as a treatment modality for this increasingly prevalent condition.

Method

Search Strategy

A comprehensive literature search was performed across PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), Scopus, and EBSCOhost. Our search terms included various combinations of "Metabolic dysfunction-associated steatotic liver disease", "MASLD", "Pediatric" "Children", "Obesity", "Aerobic exercise". We utilized Boolean operators (AND, OR) to effectively combine these terms. The search was restricted to articles published in English, with no limitations on publication date.

Study Selection and Eligibility Criteria

We included a wide range of study designs in our review. The target population consisted of published studies involving children and adolescents aged 0-18 years who had confirmed diagnosis of MASLD alongside obesity, investigating the impact of aerobic exercise on improving biomarkers related to MASLD. Aerobic exercise was defined as any structured physical activity program aimed at enhancing cardiovascular fitness, characterized by sustained, rhythmic movement involving large muscle groups.

Outcomes

Our primary outcomes focused on improvements in biochemical markers of liver function, specifically serum glutamic-oxaloacetic transaminase (SGOT/AST), serum glutamic-pyruvic transaminase (SGPT/ALT), and lipid profile parameters including total cholesterol, low-density lipoprotein (LDL) cholesterol, high density lipoprotein (HDL) cholesterol, and triglycerides. Secondary outcomes included biomarkers of metabolic dysfunction, such as homeostatic model assessment for insulin resistance (HOMA-IR), fasting insulin levels, and fasting blood glucose concentrations.

Data Extraction

The study selection process was carried out by two independent reviewers. Initially, we screened titles and abstracts against our eligibility criteria, followed by a full-text assessment of potentially relevant articles. Any disagreements between reviewers were resolved through discussion. The extracted data included study characteristics (author, publication year, study design), participant demographics (age, sex, BMI), intervention details (type, intensity, frequency, duration of aerobic exercise), and outcome measures (baseline and post-intervention values for all relevant biomarkers).

Quality Assessment and Risk of Bias

To evaluate the methodological quality and risk of bias of included studies, we employed appropriate tools based on study design. For randomized controlled trials (RCTs), we utilised the Revised Cochrane Risk of Bias tool (RoB 2), which assesses various domains, including randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of reported results. For non-randomized studies, the Risk of Bias in Non-randomized Studies of Intervention (ROBINS-I) tool was applied, which evaluates bias related to confounding, participant selection, classification of interventions, deviations from intended interventions, missing data, outcome measurement, and selection of reported results. All quality assessments were conducted by two independent reviewers, with any disagreements resolved through discussion.

Data synthesis

We presented a narrative synthesis of the findings in a tabular format to facilitate comparison across the studies included in our review. This approach allows for a clearer understanding of the impact of aerobic exercise on MASLD-related biomarkers in the pediatric population.

Result

Population and Study Characteristics

A total of 153 studies were identified in the initial comprehensive search of 4 databases. Twelve duplicate records were removed before screening, resulting in a total of 141 studies. Another 84 studies were disqualified because they were irrelevant records identified by automated screening tools. Fifty-seven studies were assessed through title and abstract, of which 14 had an incompatible study design, 15 involved deviant interventions, 12 had incompatible outcome measures, and 11 did not meet the inclusion criteria. At last, five studies were identified that fulfilled the prespecified inclusion criteria. A visual representation of our search process is provided through a PRISMA flow diagram **(Figure 1).**

The quality of each study was assessed using various tools, including the Cochrane Risk of Bias tool for RCT study designs, the Risk of Bias in Non-randomized Studies of Intervention (ROBINS-I) tool for prospective observational study designs, and the Newcastle-Ottawa Scale (NOS) tool for prospective observational studies. All the studies indicated a low risk of bias, suggesting that the findings are likely to be minimally affected by error.

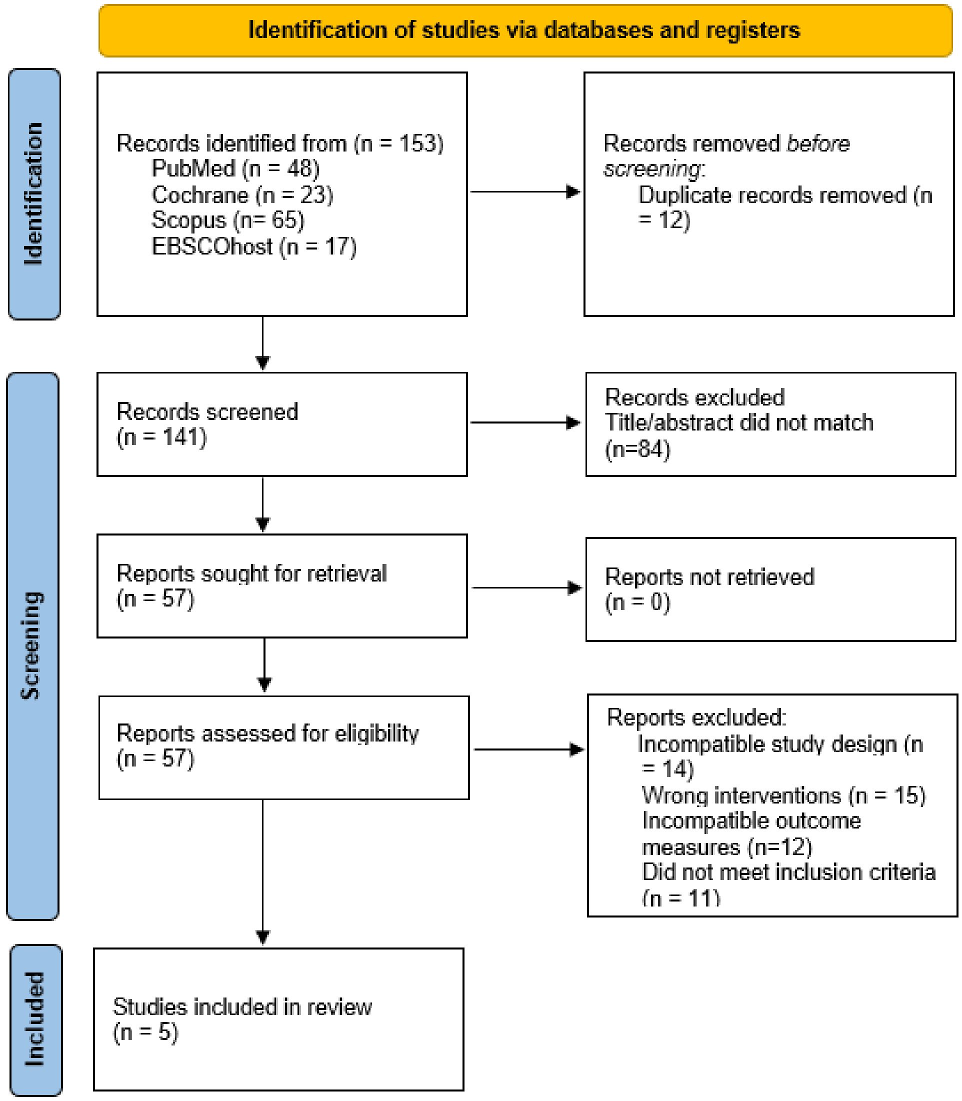

Figure 1. PRISMA flowchart

The characteristics of all eligible studies are summarized in **Table 1.** This review included 203 study participants who met the inclusion criteria for this study, which were children and adolescents aged 1-19 years, obesity as defined by their BMI, and the presence or at risk for MASLD based on their laboratory and imaging results. One study reported a 71.1% prevalence of liver steatosis during ultrasonography screening. However, this study still met the inclusion criteria, considering liver steatosis remained predominant within the study population, and they also had elevated liver enzymes, which may indicate that stress or inflammation had occurred in their liver.

Table 1. Study Characteristics

Author, Year	Study Design	Study Population			Intervention	Control	Duration	Follow up	Outcomes
		n	Obesity	MASLD					
Santomauro et al. (2012)[12]	Non-RCT	24 Children and adolescents	BMI > 97th percentile (P97) for age and sex	Confirmed by ultrasonography	Aerobic exercise (30 min daily or at least three times a week) and dietary modification	Baseline (before intervention)	12 months	12 months	• Weight (kg) • Height (cm) • BMI (kg/m²) • BMI Z-Score • Abdominal circ. (cm) • Waist/hip ratio • Fatty area (mm²) • Muscular area (mm²) • Blood Pressure (mmHg) • Calories(kcal/day) • Carbohydrates (g) • Fat (g) • Protein (g) • Physical Activity (h/week) • Exercise : yes/no (%) • Steps/day • Hours/day TV and video
Malecki et al. (2021)[13]	Prospective Observational cohort	49 Children and adolescents	BMI greater than 1-2 SD above the WHO Growth references	Confirmed MASLD based on medical history, physical examination and increased aminotransferase levels and hepatic steatosis in abdominal ultrasonograph	Aerobic exercise (60 minutes 5 times a week) and dietary modification	Baseline (before intervention)	2.45±1.45 years	Every 3 months during the first year and every 6 months afterwards during outpatient visits.	• Weight (kg) • Height (cm) • BMI (kg/m²) • ALT (IU/L) • AST (IU/L) • GGT (IU/L) • PLT (G/L) • APRI
Lefere et al. (2022)[14]	Uncontrolled prospective cohort	79 Children and adoelscents	Median BMI was 36.0 kg/m2	Liver steatosis on ultrasound was present in 71.1% of patients	Aerobic and anaerobic exercise (3 hours a week), dietary intervention and psychol	Baseline (before intervention)	11–12 months	5-6 and 11-12 months	• CAP (dB/m) • TE (kPa) • Weight (z-score) • BMI Z-Score • Waist circumference (cm) • Hip circumference (cm) • Body fat (%) • Body weight loss (%) • BMI loss (%) • ALT (U/L)

Author, Year	Study Design	Study Population			Intervention	Control	Duration	Follow up	Outcomes
		n	Obesity	MASLD					
					ogical support				• AST (U/L) • Total cholesterol (mg/dL) • HDL cholesterol (mg/dL) • LDL cholesterol (mg/dL) • Triglycerides (mg/dL) • Glucose (mg/dL) • Insulin (mIU/L) • HOMA-IR • hs-CRP (mg/dL)
de Piano et al. (2012)[15]	RCT	14 adolescents	BMI was 36.55±4.6 kg/m2	MASLD according to ultrasonography	Aerobic vs aerobic + resistance training and dietary modification (60-min session three times a week)	Baseline (before intervention)	12 months	12 months	• Weight (kg) • BMI (kg/m²) • Fat mass (%) • Fat mass (kg) • Lean mass (kg) • Visceral (cm) • Sub (cm) • Glycemia • Insulin • HOMA-IR • Total cholesterol (mg/dL) • LDL cholesterol (mg/dL) • VLDL • HDL cholesterol (mg/dL) • Triglycerides (mg/dL) • AST • ALT • GGT
Tas et al. (2023)[16]	RCT	37 adolescents	BMI ≥ 95th percentile for age and sex	High risk for MASLD, defined as VCTE-CAP ≥ 241 dB/m	4-week supervised HIIT program (60 minutes, 3 times a week)	No exercise	1 month	1 month	• Weight (kg) • BMI z-score • Body fat percent (%) • LBM (kg) • Visceral fat area (cm2) • IHTG (%) • CAP score (dB/m) • LSM Score (Kpa) • VO2 peak (ml.min/kg per • LBM • Fasting glucose (mg/dL) • 2h-glucose (mg/dL) • Fasting insulin (uIU/mL) • 2h-Insulin (uIU/mL) • HOMA-IR

Author, Year	Study Design	Study Population n	Obesity	MASLD	Intervention	Control	Duration	Follow up	Outcomes
									• TC (mg/dL) • HDL-c (mg/dL) • LDL (md/dL) • TG (mg/dL) • ALT (IU/L) • AST (IU/L) • Adiponectin ng/ml) • Lepttin (pg/mL) • FGF-21 (pg/mL)

ALT: Alanine Aminotransferase; APRI: AST-to-Platelet Ratio Index; AST: Aspartate Aminotransferase; BMI: Body Mass Index; CAP: Controlled Attenuation Parameter; FGF-21: Fibroblast Growth Factor-21; GGT: Gamma-Glutamyl Transferase; HDL: High-Density Lipoprotein Cholesterol; HOMA-IR: Homeostatic Model Assessment for Insulin Resistance; IHTG: Intrahepatic Triglyceride Content; LDL: Low-Density Lipoprotein Cholesterol; LSM: Liver Stiffness Measurement; PLT: Platelet Count; RCT: Randomized Controlled Trial; TC: Total Cholesterol; TE: Transient Elastography; TG: Triglycerides; VCTE: Vibration-Controlled Transient Elastography; VLDL: Very Low-Density Lipoprotein; VO2 peak: Peak Oxygen Consumption; hs-CRP: High-Sensitivity C-Reactive Protein

All the studies utilized aerobic exercise as their initial intervention. One of the studies included a HIIT exercise program as an intervention, but since HIIT also involves cycles of intense aerobic exercise, we consider it still suitable.[16] Four of the five studies included an intervention on their daily diets, and one of them also provided psychological support as an additional intervention.[14] The intensity of aerobic exercise was varied, ranging from 30 minutes to 60 minutes per training session, with 3 to 5 training sessions per week. This aerobic exercise was observed over a period ranging from 1 month to 2.5 years, with a comparative group before and after the intervention. However, one of five studies compared exercise with no exercise. The outcomes of the studies are summarized in terms of body composition, liver enzymes, lipid profile, laboratory metabolic markers, and liver imaging, using various indicators.

Body Composition

Elevated BMI is consistently associated with a higher incidence and greater severity of MASLD, particularly when accompanied by increased visceral fat distribution.[17] Aerobic exercise is reported to reduce fat mass and lead to a decrease in body weight.[18] This study demonstrated a significant improvement in BMI for age Z-score and BMI (kg/m^2) among pediatric patients with or at high risk of MASLD and obesity in 2 of 3 studies following aerobic exercise training.[12, 14] Another study also reported an improvement, although it was not statistically significant.[16] Changes in BMI for age Z-score and BMI (kg/m^2) were calculated based on the study results and reported as a delta (Δ) value, showing a reduction ranging from Δ –0.27 to –1.00 and Δ –0.03 to –1.00, respectively.

Divergent findings were found in Lean body mass (kg) and visceral fat area (cm^2). Two studies on lean body mass showed an increase (52.02 to 52.04) and a decrease (63.42 ± 7.39 to 3.69 ± 1.37), although the changes were not statistically significant.[12, 16] While 2 studies reported a significant loss (6.31±1.33 to 62.45±7.58) and insignificant gain (95.78 to 95.85) of visceral fat area (cm^2).[15, 16] These findings suggest that while BMI-related indicators consistently improved with aerobic exercise, the effects on lean body mass and visceral fat area remain inconclusive.

Liver Enzyme

Liver enzymes had an essential role in early detection, monitoring therapy and assessing the progression of MASLD. Alanine Aminotransferase (ALT) is commonly used as a marker of improvement in the histology of MALSD, as ALT is mainly found in hepatocytes.[19] All of the reviewed studies included Aspartate Aminotransferase (AST) and ALT as their outcomes and observed a reduction following aerobic exercise training. A significant reduction was reported in 3 of 5 studies with delta values of AST ranging from Δ –1.00 to –34.00, and also ALT ranging from Δ –1.00 to –27.17 IU/L.[12-14] The other 2 of 5 studies also showed a reduction in levels of AST and ALT, with delta values ranging from Δ –0.86 to –5.50 and Δ –0.53 to –7.0, although these differences were not statistically significant.[15, 16] These findings suggest that aerobic exercise may contribute to improvements in hepatic inflammation and liver enzyme profiles in pediatric patients with or at risk of MASLD, even when statistical significance is not consistently achieved.

Lipid Profile

Circulating lipids, such as Free Fatty Acids, Very Low-Density Lipoprotein, Low-Density Lipoprotein, and high-density lipoprotein, play an essential role in the development of MASLD.[20] Aerobic exercise intervention showed mixed effects on lipid profile. Total cholesterol was reported to significantly decrease in 2 of 4 studies, with delta values ranging from Δ –32.00 to +1.00 mg/dL.[14, 16] As seen in total cholesterol, LDL levels also showed a significant decrease in 3 of 4 studies, with delta values ranging from Δ –11.55 to +2.38 mg/dL.[12, 14, 16] HDL levels exhibited mixed responses across studies, with 2 reporting increases[12, 15] and 2 reporting decreases following aerobic exercise training intervention.[14, 16] HDL was reported to have a significant increase in 1 of 2 studies (36.95±9.58 to 44.08±12.95) mg/dL, while the other one reported an insignificant increase of HDL (45.07±9.35 to 47.23±12.2) mg/dL. Triglyceride levels were mentioned with no significant change in 3 of 4 studies reviewed.[12, 14-16] Overall, aerobic exercise demonstrated a favourable effect on total cholesterol and LDL levels in pediatric patients with or at risk of MASLD. At the same time, its impact on HDL and triglycerides appeared more variable and less consistent across studies.

Metabolic Dysfunction Markers

MASLD often coincides with other metabolic disease, especially with diabetes mellitus.[20] These studies conclude that aerobic exercise does not significantly affect metabolic dysfunction markers. It reported that 3 of 4 studies showed no significant change in fasting glucose, although 2 studies reported a decrease in fasting glucose with delta values ranging from Δ -0.35 to -4.00 mg/dL.[12, 15, 16] 1 of 2 studies showed a significant change in 2-hour glucose level of 11.54mg/dL.[16] Fasting insulin on the contrary, revealed a reduction in 4 studies with 2 studies having significant delta values ranging from Δ-2.84 to -8.90 mIU/L.[12, 14] Similarly with fasting insulin, 2 hour insulin also revealed a reduction in 2 of 2 studies with delta values ranging from Δ -9.39 to -4.75 mIU/L.[12, 16] However, Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) reported a significant decrease in 2 of 4 studies with delta values ranging from Δ-0.58 to -2.40.[12, 14] Another hormone, adiponectin level, showed an insignificant decrease in 2 of 2 studies with delta values ranging from Δ -1.38 to -0.32 ng/mL.[15, 16] Last, the leptin hormone showed divergent insignificant results in 2 of 2 studies with delta values ranging from Δ -1.77 to +5.03 pg/mL.[15, 16] A minority of studies reported limited effectiveness in improving metabolic markers in patients with MASLD.

Liver Imaging

Radiology examinations are included in 3 of 5 studies using ultrasonography (USG), FibroScan and Magnetic Resonance Imaging (MRI) as examination tools.[12, 14, 16] A study reported that the Intrahepatic Triglyceride Content (IHTG) measured by MRI Proton Density Fat Fraction (MRI-PDFF) was significantly decreased from 8.81% to 7.76% after HIIT training, while the control group reported a non-significant decrease ($\Delta = -1.12$ pp, $p = 0.182$). The Controlled Attenuation Parameter (CAP) score after HIIT training also decreases significantly from 279 dB/m to 252 dB/m, while in the control group, the CAP also decreased ($\Delta = -16$ dB/m, $p = 0.359$), but it is insignificant. [16]

Another study reported that after 6 months of aerobic exercise intervention, the resolution of steatosis occurred in 47.1% patients with steatosis baseline. Regression of fibrosis was observed in 75% of patients with fibrosis at baseline, while resolution of fibrosis (TE < 7 kPa) was achieved in 62.5% of patients. After 11-12 months, this study reported a 94.5% improvement and a 78.2% resolution of patients with MASLD at baseline ($p < 0.001$), based on USG and CAP scores.[14]

The third study performed liver USG at baseline and after intervention. The results were classified into mild, moderate, and severe MASLD. After intervention, the MASLD conditions disappeared in 37.5% patients. A significant improvement (P =

0.03) was observed after the intervention, where 30.6% of those with mild MASLD reduced to 22.2%, 27.8% of those with moderate MASLD reduced to 13.9%, and 8.3% of those with severe MASLD reduced to 5.6%. Collectively, radiological assessments across the included studies consistently demonstrated significant improvements in hepatic steatosis and fibrosis following aerobic exercise interventions, as evidenced by reductions in MRI-PDFF, CAP scores, and FibroScan values, as well as resolution rates observed on ultrasonography.[12]

Discussion

The systematic review evaluated the therapeutic role of aerobic exercise in obese children and adolescents with or at high risk of MASLD. Overall, the 5 included studies revealed differences in study design, but the population and interventions were uniform. Most studies employed RCTs with sample sizes ranging from 14 to 79 participants, aged from 3 years to 18 years old. All the studies included aerobic exercise as their initial intervention, with training sessions lasting 30 to 60 minutes and occurring 3 to 5 times per week over 1 to 12 months. These studies primarily compare outcomes before and after an intervention, including body composition, liver enzymes, lipid profile, laboratory metabolic markers, and liver imaging. All studies have a low risk of bias.

Exercise is widely accepted as a beneficial treatment for MASLD, as a sedentary lifestyle, poor aerobic fitness, and low muscle mass are all recognized risk factors for the condition.[21] In this review, aerobic exercise led to clinically meaningful reductions in BMI-related indicators consistently, an effect that has similarly been demonstrated in prior pediatric studies on obesity and MASLD risk. These findings align with a study a study from Regaieg et al. where 28 obese children participated an aerobic exercise over 16-week, with four 60-min sessions per week at 70-85% of maximum heart rate showed significant reduction in BMI and waist circumference compared with the baseline values ($p<0.001$).[22] However another study revealed an inconsistent results where an aerobic training program with 60 minutes session per week over 24 months in children induced no significant differences in BMI ratio and z-score ($p>0.9$) in the measured variables compared to controls at the final follow up, consistent with BMI, study also demonstrated no significant changes in the fat-free mass index ($p>0.07$).[23] BMI does not accurately represent body composition and is less effective than waist circumference in predicting metabolic dysregulation, the hepatic manifestation of which is MASLD.[24] It has also been shown to overlook more than a quarter of children with excess body fat.[25]

The effects of aerobic exercise on lean body mass and visceral fat area in children with MASLD remain inconclusive, likely due to variations in body composition responses that depend on other factors such as exercise modality, duration, and intensity.[26] Nevertheless, aerobic training is commonly prioritized in the development of fat loss programs, as it incorporates strategies designed to optimize fat oxidation intensity and includes high-intensity interval training.[27] This approach is well-supported by substantial evidence highlighting its effectiveness in reducing visceral fat and improving metabolic health.[28] However, in a study where energy expenditure was standardized, no consistent differences were found between moderate continuous aerobic exercise and high-intensity interval training. These findings imply that total energy expenditure, which is determined by the duration and intensity of the exercise, may be a more crucial factor in fat reduction than the specific training modality itself.[29]

Even though statistically inconsistent, liver enzymes, particularly ALT and AST, showed improvements after aerobic exercise interventions in obese children and adolescent patients with or at risk of MASLD, indicating decreased hepatocellular injury and inflammation. Likewise, a study by Malecki et al. studied 49 children and adolescents, ages 3 to 16, diagnosed with NAFLD through ultrasound. They were prescribed a Mediterranean diet and moderate-intensity aerobic exercise lasting at least 60 minutes five days per week. The participants were followed for an average of 2.45 ± 1.45 years. The study revealed a decrease in aspartate aminotransferase AST and alanine aminotransferase ALT levels in all patients, even those who did not show a reduction in BMI.[13] Increased transaminase levels are recognized as an independent predictor of advanced fibrosis and have been shown to have a significant correlation with nonalcoholic steatohepatitis.[30]

Aerobic exercise also demonstrated favourable reductions in total cholesterol and LDL levels. However, its impact on HDL and triglycerides appeared more variable and less consistent across studies. This effect is likely due to its ability to improve mitochondrial fatty-acid oxidation in the liver, up-regulating the expression of genes such as PPARα and CPT1a. At the same time, aerobic exercise down-regulates lipogenesis by suppressing lipogenic factors like SREBP-1c and FAS, a pattern that is associated with a reduction in hepatic triglyceride accumulation. [31] In contrast, markers of glucose metabolism, including fasting glucose, fasting insulin, and HOMA-IR, showed limited improvements. These studies conclude that aerobic exercise does not significantly affect markers of metabolic dysfunction in these limited studies. This may be due to the relatively short duration of the exercise interventions, which may not be long enough to induce significant changes in glucose metabolism. Additionally, the absence of dietary interventions in several of these studies could also limit the impact of aerobic exercise on insulin sensitivity and glucose regulation.[32]

The results from the studies demonstrate the positive impact of aerobic exercise interventions on hepatic steatosis and fibrosis in pediatric patients with MASLD, as assessed through various radiological methods including USG, FibroScan, and MRI. Notably, aerobic exercise led to clinically significant improvements in MRI-measured liver fat, independent of substantial weight loss.[33] Moreover, more than 30% relative reduction in MRI-measured liver fat was observed in patients with MASLD who were prescribed with 150 min/week of moderate-intensity aerobic exercise, which is similar to outcomes reported in early-phase MASLD drug trials primarily focused on antisteatogenic medications.[34] The significant improvements observed across multiple imaging modalities underscore the importance of these findings, further supporting the integration of aerobic exercise into clinical practice for the management of MASLD in children.

This review has several limitations. The number of eligible studies was small, and most had limited sample sizes, reducing statistical power. Additionally, the interventions varied across studies, and a meta-analysis could not be conducted. Nonetheless, this systematic review provides valuable insight into the potential effects of aerobic exercise on MASLD.

Conclusion

This systematic review revealed that aerobic exercise showed selective benefits to pediatric and adolescent with MASLD and obesity. Significant improvements were found in BMI and liver enzymes in several studies. Radiology examination also showed improvement in the resolution of liver steatosis. However, the effect on lipid profile and metabolic markers showed inconsistent improvement. The overall findings support aerobic exercise as a safe and effective non-pharmacologic intervention. Integration of structured aerobic exercise into standard management strategies for pediatric MASLD may enhance clinical outcomes, though further high-quality RCT are needed to define optimal exercise protocols and long-term effects.

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Conflict of Interest

There is no conflict of interest.

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