

**Martial Arts Training Effects on Health Markers in Adolescents and Children: A
Systematic Review**

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Abstract

Introduction: Childhood obesity has been a growing concern over the past 50 years in the United States. Healthcare providers have extensively studied childhood obesity, yet the rates continue to rise. Obesity contributes to lifelong health complications including cardiovascular disease, hyperlipidemia, hypertension, type 2 diabetes mellitus, and certain cancers. A disproportionate number of Hispanic and non-Hispanic Black children are affected by childhood obesity. Childhood obesity also contributes to the overall economic burden on the healthcare industry. **Methods:** A review of literature was conducted using PubMed, CINAHL, MEDLINE, and ScienceDirect databases. Articles included in the systematic review must meet the following inclusion criteria: published between 2017 to 2023, report primary research, peer reviewed, written in English, and they must address the effectiveness of martial arts on improving health markers in children. **Results:** A total of 434 articles were identified and of those articles seven met the inclusion criteria. Common themes across studies were an increase in cardiovascular fitness from martial arts as well as an improvement in body composition due to martial arts training. **Discussion:** The major findings were improvements in cardiovascular fitness and improvement in body composition. Studies suggest that martial arts could be a feasible method of increasing physical activity and reducing body fat. Some studies suggest that increase in other health markers, such as increases in lean body mass, could be achieved through martial arts. The results were inconclusive on the effects of martial arts on BMI.

Keywords: childhood obesity, martial arts, cardiovascular fitness, BMI

Martial Arts Training Effects on Health Markers in Adolescents and Children: A Systematic Review

From 1965 to 2018 the rates of obesity went from less than 5% to almost 20% (Fryar et al., 2020). Childhood obesity has been a growing concern for decades in the United States of America. Much research has been conducted regarding childhood obesity and ways to prevent and treat it, yet, healthcare providers, have had very little real-world impact on childhood obesity rates. Childhood obesity contributes to increased risk for cardiovascular disease, hyperlipidemia, hypertension, type 2 diabetes mellitus, and certain cancers (Centers for Disease Control and Prevention, 2022). Childhood obesity also contributes to economic burden on the healthcare industry by increasing direct healthcare cost of \$237.55 per capita yearly (Ling et al., 2022). Given the burden of disease and economics associated with childhood obesity, innovative interventions that appeal to children and adolescents need to be explored to determine their effects on child health behaviors and indicators of childhood obesity. Martial arts can be an innovative activity that increases physical activity. While there may be secondary benefits to martial arts, this systematic review will analyze research on the effectiveness of various martial arts to improve health markers.

Background and Significance

Childhood obesity rates began to level off during the early 2000's, but rates have recently begun to increase once again during the COVID-19 pandemic. Since the beginning of the pandemic, the already increasing rates doubled in both childhood and adolescent obesity (Ling et al., 2022). Obesity in children and adolescents is defined as a BMI of 95% or greater based on Centers for Disease Control and Prevention growth charts (Centers for Disease Control and Prevention, 2021). Based on CDC data, there is a disparity of obesity in some ethnicities.

The highest rates of childhood and adolescent obesity in the United States are in the Hispanic population which has a childhood obesity rate of 26.2% compared with 16.6% of white children (Centers for Disease Control and Prevention, 2022a). A similarly high percentage is found in non-Hispanic Black children and adolescents at 24.8% (Centers for Disease Control and Prevention, 2022a).

The problem of obesity can be a direct result of both an increase in calorie intake as well as a decrease in calorie expenditure. This review will be focused on the problem of energy expenditure. The Department of Health and Human Services (2018) recommends children six through 17 years of age participate in at least 60 minutes of moderate to vigorous activity daily. In addition, they recommend a combination of aerobic, muscle strengthening, and bone strengthening activities. They do not specifically indicate what metric should be used to define moderate or vigorous activity, but they do provide examples. Activities such as walking or biking are described as moderate. Martial Arts are described as a vigorous activity for both children and adolescents (U.S. Department of Health and Human Services, 2018). Less than 24% of children ages six through 17 meet the 60 minutes of physical activity recommended (Centers for Disease Control and Prevention, 2022b). The southern United States has the lowest participation rates in organized sports nationally which contributes to decreased physical activity and tends to increase obesity (Black et al., 2022).

Review of the Literature

Exercise as an intervention for obesity is not a new concept. Many researchers have evaluated methods for weight loss through exercise modalities. Evidence suggests that exercise is an excellent way to improve health markers. According to the CDC, exercise helps maintain a healthy weight, reduces risk of developing type 2 diabetes mellitus, decreases blood pressure,

and decreases risks for several cancers (Centers for Disease Control and Prevention, 2023). Exercise can also improve cognition for children aged six to 13 years of age (Centers for Disease Control and Prevention, 2023). Martial arts have long been a hobby practiced by youth and adults. Some literature suggests martial arts would be an effective modality to improve cardiovascular fitness, healthy BMI, and improve strength and flexibility (Brazil et al., 2020; Chainok et al., 2022; Saraiva et al., 2021). The research has limitations, and there are conflicting results among studies.

A systematic review of literature on Judo found that nine months of Judo was effective for decreasing body fat, increasing lean muscle mass, and improvements in bone health (Kowalczyk et al., 2023). This review examined 16 studies, with the participants' averaged 10 years of age. Five of the studies used normal physical education classes as a control group. Training sessions conducted were between 45 to 90 minutes of physical activity per training session two to four times per week. This literature review exclusively evaluated Judo and no other martial arts, and they did not specifically target obese children as the primary participants. The participants had BMI from 5%-85% compared to the WHO standardized growth charts based on age (Kowalczyk et al., 2023). The study also found limited mixed gender studies and girls were heavily underrepresented (Kowalczyk et al., 2023).

Another systematic review evaluated martial arts as an intervention for BMI reduction and body fat reduction. They reviewed five articles that mainly focused on Tai Chi and Kung Fu as the intervention. The sessions of intervention ranged from 45 minutes to two hours, two to five times per week. The interventions included traditional Kung Fu and Tai Chi poses (de Souza et al., 2020). This study did not consistently find that martial arts reduced body fat or BMI. The study did not focus exclusively on children, though it did include children and adolescents.

Evidence is somewhat limited on initial inquiry of martial arts as a modality for reduction of obesity and improvement in cardiovascular health over other interventions. Evidence seems encouraging for this as an innovative modality, but further investigation needs to be conducted given the conflicting systematic reviews. This systematic review will seek to clarify the health promotion effects of martial arts, and potentially seek specific martial arts that are the most beneficial.

Purpose and Clinical Question

Since children and adolescents are not getting enough physical activity, finding exercise modalities that will be adhered to and enjoyed would be beneficial. To our knowledge, there is no systematic review that evaluates the beneficial effects of martial arts to combat obesity in children and adolescents as compared to other modalities. Therefore, a systematic review of literature was conducted to clarify the use of martial arts for health promotion with the intention of evaluating innovative ideas to increase physical activity for children and adolescents. The question being investigated is: In children 8-18 years, does participation in a martial arts-related physical activity improve obesity-related measures such as weight, BMI, and cardiovascular fitness compared to usual interventions and other sports?

Conceptual Framework

The conceptual framework that inspired this work was Nola Pender's Health Promotion Model. This model seeks to understand what makes people choose to improve health behaviors and seeks to guide the nurse in assisting people during counseling of health-promoting behaviors. Specifically, this model aided this review by guiding search parameters in recognizing the context of an individual's environment will help behavioral outcomes. Martial arts are typically conducted in groups or classes, and the Health Promotion Model recognizes having other peers

or significant others exhibiting similar changes will help facilitate behavior change (Pender, 1996).

Methods

Project Design

This paper will use a systematic review of the literature as a design for compiling data relevant to the question of martial arts' impact on childhood obesity and related health markers stated previously. This study is needed to evaluate martial arts as a recommendation for health promotion and physical activity to reduce obesity and improve related health markers. Pender's health promotion model helps guide this systematic review of literature.

Search Strategy

A review of literature was conducted using PubMed, CINAHL, MEDLINE, and ScienceDirect databases. The search terms used were "martial arts" in combination with "childhood obesity," "metabolic rates in children," "BMI," "cardiovascular fitness," "lean muscle mass," "health outcomes," "health benefits," and "physical fitness." To be included in the review, the article needed to: be published between 2017 to 2023 and report primary research. Articles must have been peer reviewed, written in English, and must address the effectiveness of martial arts on improving health markers in children. A rapid critical appraisal for randomized clinical trials was used (Melnik & Fineout-Overholt, 2018). A system of 11 points was devised and any score over five would qualify the study to be included in the review.

Selection Process

The PRISMA 2020 flow diagram was used to document the screening of studies to conclude with the final sample. See Figure 1. PubMed, CINAHL, MEDLINE, and ScienceDirect databases were searched for relevant research articles that met inclusion criteria. Articles were

reviewed by the author independently, and were evaluated by title, abstract, then full text article. This systematic review includes randomized controlled trials and quasi-experimental trials. The Melnyk and Fineout-Overholt (2019) Rapid Critical Appraisal tool was used to evaluate the validity and reliability of the article.

The rapid critical appraisal questions ensure the validity of the study by evaluating methods such as how the study was randomized, if the study was conducted for a long enough period to appreciate a change, and if this study is applicable to clinical practice (Melnik & Fineout-Overholt, 2019).

Results

Search Results

A total of 434 articles were identified (see figure 1). Five duplicate articles were removed and 399 were removed based on the title. Thirty-four articles were reviewed further by reading the abstract. Twenty-five articles were removed based on relevance to the research question, and two more were removed based on inappropriate age ranges to address the focus of this systematic review. Seven articles were included in this systematic review of literature that pertained to the research question and relevant age groups.

Characteristics of Studies

The seven articles were evaluated using the evidence synthesis table (Table 1) to organize data. Of the seven articles, three were quasi-experimental (Brasil et al., 2020; Nyré & Lopuszanska-Dawid, 2023; Saraiva et al., 2021) and four were randomized controlled studies (Chainok et al., 2022; de Souza et al., 2022; Pinto-Escalona et al., 2021; Roh et al., 2020). One of the studies ~~were~~was aimed at evaluating martial arts as a method of reducing obesity (Brazil et al., 2020). Most of the studies more broadly examined body mass index, or BMI, and the

improvement of physical fitness through activity (Chainok et al., 2022; de Souza et al., 2022; Nyrć & Lopuszanska-Dawid, 2023; Pinto-Escalona et al., 2021; Roh et al., 2020). Other metrics observed were metabolic changes secondary to the martial arts interventions (de Souza et al., 2022). The sample sizes ranged from 20 (Roh et al., 2020) -721 (Pinto-Escalona et al., 2021) throughout the various studies. The total sample size was 948 across all studies.

The settings of these studies ranged from Europe (Pinto-Escalona et al., 2021; Nyrć & Lopuszanska-Dawid, 2023), Brazil (Brasil et al., 2020; de Souza et al., 2022; Saraiva et al., 2021), Korea (Roh et al., 2020), and Thailand (Chainok et al., 2022). Most of the studies placed a control group that maintained current levels of activity (Pinto-Escalona et al., 2021; Roh et al., 2020) or were instructed on non-active lifestyle modifications (de Souza et al., 2020). One study compared aerobic activity and weightlifting to a martial arts high-intensity interval training group (Chainok et al., 2022). The studies largely included [an](#) intervention group being instructed in various martial arts for anywhere from eight weeks (Chainok et al., 2022) to 16 weeks (Saraiva et al., 2021).

BMI and body composition were the most studied metrics evaluated across studies (Brasil et al., 2020; Chainok et al., 2022; de Souza et al., 2022; Nyrć & Lopuszanska-Dawid, 2023; Pinto-Escalona et al., 2021; Roh et al., 2020; Saraiva et al., 2021). Data collection was done with various implements including DEXA scan (Brasil et al., 2020). One study attempted to correlate the adolescents' BMI to that of the parents to determine the role of the parent as mentor (Nyrć & Lopuszanska-Dawid, 2023).

Synthesis Across Studies

Using the Whittemore and Knafl thematic analysis methods, two major themes were identified across multiple studies, including various forms of martial arts used as an intervention (2005).

Theme 1: Increase in Cardiovascular Fitness

Despite the multiple martial arts studied, most of the studies strongly suggest improvements in cardiovascular fitness over the respective control groups (Brasil et al., 2020; Chainok et al., 2022; de Souza et al., 2022; Nyrć & Lopuszanska-Dawid, 2023; Pinto-Escalona et al., 2021). Many different methods were used to determine cardiovascular fitness. Most studies used some physical fitness and endurance testing. One study used resting heart rate as a measure of cardiovascular fitness (de Souza et al., 2022). Five of the six articles that evaluated cardiovascular fitness found an improvement over the control group (Brasil et al., 2020; Chainok et al., 2022; de Souza et al., 2022; Nyrć & Lopuszanska-Dawid, 2023; Pinto-Escalona et al., 2021). One study found statistical improvement using VO2max as the qualifier for fitness (Brasil et al., 2020). Karate outperformed physical education classes in improvements in cardiovascular fitness (Pinto-Escalona et al., 2021). Muay Thai showed a larger improvement in cardiovascular fitness than a combination of weightlifting and aerobic exercise in another study (Chainok et al., 2022).

Theme 2: Improvements in Body Composition

All four of the studies that measured body composition showed a statistically significant improvement in body composition (Brasil et al., 2020; Nyrć & Lopuszanska-Dawid, 2023; Roh et al., 2020; Saraiva et al., 2021). They all found a decrease in adiposity and an increase in lean muscle mass regardless of effect on BMI (Brasil et al., 2020; Nyrć & Lopuszanska-Dawid, 2023;

Roh et al., 2020; Saraiva et al., 2021). One study indicated a body fat loss around the abdomen as well as an increase in lean muscle throughout the body (Saraiva et al., 2021).

Nonthematic Commonalities and Other Relevant Findings

One other commonality was recognized across studies. Two of the studies found a reduction in BMI and significant weight loss (Roh et al., 2020; Saraiva et al., 2021). BMI reduction was not observed in many of the studies that included BMI as a parameter measured (Brazil et al., 2020; Nyrce & Lopuszanska-Dawid, 2023). This calls into question how reliably we can recommend martial arts for a reduction in BMI or weight loss. One study measured other health markers including lipids and triglycerides. They noted a significant reduction in these markers which could prevent future health concerns (de Souza et al., 2022).

Discussion

Obesity in childhood and adolescence is a major health concern in the United States as evidenced by the increase in obesity since 1965 (Fryar et al., 2020). This systematic review is aimed at determining if martial arts is an innovative way to combat obesity in childhood and adolescents. Innovative solutions are needed to combat the decrease in physical activity and increase in obesity. Karate, Judo, Muay Thai, and Taekwondo have been studied to evaluate the effectiveness of martial arts to improve health and reduce BMI. Across the various martial arts improvements in health were observed. The major findings were improvements in cardiovascular fitness and improvement in body composition. Studies suggest that martial arts could be a possible method of increasing physical activity and reducing body fat. Some studies suggest that increase in other health markers, such as increases in lean body mass, could be achieved through martial arts.

Recommendations from Findings

This systematic review was intended to determine the effectiveness of martial arts for reducing childhood obesity and improving health metrics. Only five martial arts were evaluated in this review due to inclusion criteria. There could be some discrepancy in the physical intensity of various subsets of martial arts.

In a systematic review by Kowalczyk et. al., (2023), an improvement in body fat and lean muscle was found in a judo intervention. This systematic review attempted to broaden this finding out to other martial arts and further solidify martial arts as a valid recommendation for improvements in health. Another systematic review by de Souza et al. (2020) found martial arts did not benefit body fat percentage or BMI. This study focused on Tai Chi and Kung Fu, which were not evaluated in this systematic review based on search parameters.

The results of this systematic review did not demonstrate reliable and repeatable decreases in BMI. There are several possibilities for why studies did not show a reduction in BMI. One such reason is the brevity of these studies. Most of the studies revealed a reduction in body fat and improved lean muscle mass (Brazil et al., 2020; Saraiva et al., 2021; Chainok et al., 2022). Given enough time, a reduction in BMI may have potentially been appreciated. The most likely reason for the lack of BMI reduction is that nutrition was not part of the intervention. Even with an increase in energy expenditure, a control for calorie intake is needed for weight reduction. The study that did show an improvement in BMI had the participants track their food intake in a log (Roh et al., 2020).

After review of the literature, the studies suggest that martial arts can be effective for health promotion. Research does suggest that the martial art recommendation makes a difference and one that meets the moderate to high-intensity physical activity should be recommended over low intensity martial arts. Martial arts such as Judo, Muay Thai, Karate, and Taekwondo were

found to be moderate to high intensity and are effective for body fat reduction (Brazil et al., 2020; Nyrć & Lopuszanska-Dawid, 2023; Roh et al., 2020; Saraiva et al., 2021). Martial arts such as Tai Chi and Kung Fu were not effective for body fat reduction (de Souza et al., 2020). The moderate to high-intensity martial arts are effective for patients that are seeking to increase lean mass and improve cardiovascular fitness (Brazil et al., 2020; Nyrć & Lopuszanska-Dawid, 2023; Roh et al., 2020; Saraiva et al., 2021). Advanced Practice Nurses and Primary Care Providers need to keep martial arts in mind when working with patients to improve lean body mass and cardiovascular fitness.

Limitations

There were limitations to this systematic review. While most of these studies were randomized controlled studies, most had very small sample sizes (Brazil et al., 2020; Chainok, 2022; Roh et al., 2020; Saraiva et al., 2021). This could be the case due to the necessity of trained instructors in specialized technique related to the particular martial art. Another reason for the limited sample size could be due to lack of participation by the population due to the intensity of the program. Future studies could focus more on recruitment and ensuring enough instructors are available. Another major limitation is the lack of studies in the diverse populations in the USA. Most studies were limited to Brazil, South Korea, and Poland which are largely homogenous in nature. These countries may have a difference in both culture and values that might not translate to American culture and values. The United States of America has a very diverse population with various cultural practices. Countries like South Korea and Brazil have a long history of cultural interest in martial arts. More cross-cultural studies should be done in the future. Another limitation was a lack of tracking of other health metrics. Only one of the studies

evaluated effects on blood pressure, lipids, triglycerides, and blood glucose levels that are relevant to long term health.

Conclusions and Implications

Physical activity guidelines are currently being met by less than 24% of children ages 6-17 (Centers for Disease Control and Prevention, 2022). Recommending new and interesting methods of increasing physical activity could help to meet the recommendations given by the Department of Health and Human Services (U.S. Department of Health and Human Services, 2018). APRNs and providers should recommend certain martial arts that constitute moderate to high intensity training to obese children and adolescents. This includes Judo, Karate, Taekwondo, and Muay Thai. This recommendation should be given as a part of other healthy lifestyle modifications as martial arts alone did not consistently demonstrate a reduction in BMI, even though a decrease in body fat and increase in lean muscle mass were demonstrated. This systematic review did not investigate safety or injury rates associated with engaging in moderate or high-intensity martial arts, but safety measures should be discussed prior to initiating training.

Additional research is needed to evaluate martial arts' effects on BMI. Long term studies should be conducted to evaluate changes in BMI over more than four months. Three to four months of training in any activity may not show BMI reduction. A study evaluating high-intensity interval training, which is similar intensity to martial arts, showed a reduction in BMI over 23 weeks of training (Espinoza Silva et al., 2023). Similarly, more studies should be conducted to evaluate health markers such as effects on blood pressure, insulin sensitivity, cholesterol, and triglycerides. Follow-up studies that show adherence to martial arts programs over years would also be helpful to show martial arts can be a lifelong activity stretching into adulthood and helping prevent adult obesity. Studies need to be done in the United States to

evaluate martial arts with the diverse population and culture. While the studies evaluated in this systematic review were across cultures and countries, the United States has a different culture and one that does not have a long-standing engrained tradition of martial arts participation across the entire population.

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Figure 1
Flow diagram of systematic review process

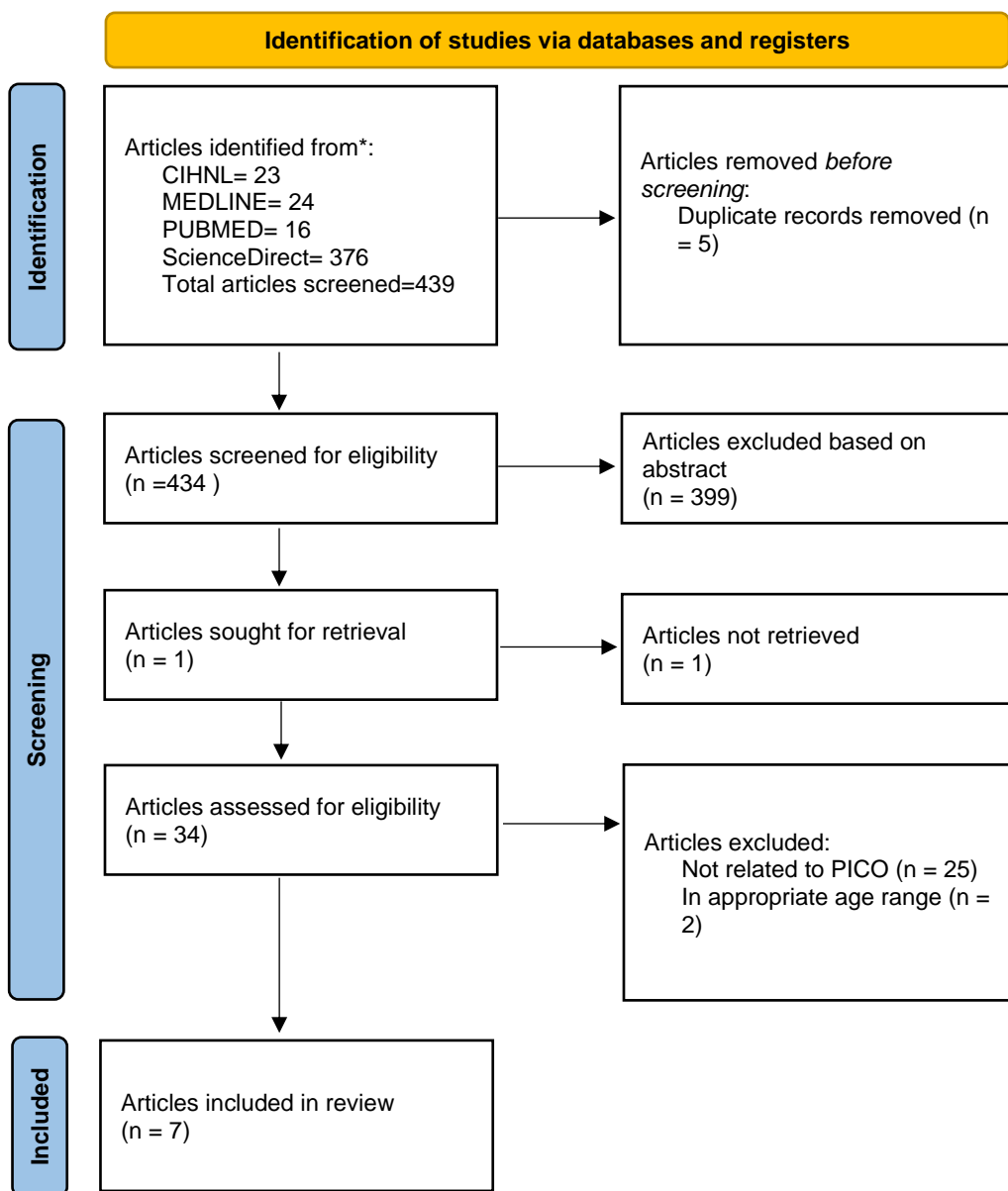


Table 1
Evidence Synthesis Table

Author	Purpose	Design	Sample/ Setting	Methods	Findings	Quality Appraisal/ Limitations	Conclusions/ Application
Brazil, 2020	To evaluate if martial arts could be a valid response to the obesity epidemic.	Quasi-experimental	35 obese participants in Brazil. 20 Obese 15 non-obese. 10 of the intervention group were boys, 10 girls. Average age 11.1 years.	Participants separated into 2 categories, obese and non-obese. intervention was 12-week 60-minute program of judo for beginners. BMI and WC. BFP and free fat mass were measured with DEXA scan. CPTs were conducted. BP was measured by auscultation by the same researcher.	BODY COMPOSITION: No change in BMI was observed. Lean body mass was improved. Effect size of 0.54 with CI of 95%. Cardiopulmonary fitness: Improved VO ₂ peak in Obese individuals Effect size of 0.24 w/ 95% CI. Similar overall improvement in CP fitness in both obese and non obese participants.	Quality Appraisal 8/11 Limitations: Small sample size. High drop out rate Lack of true control group. Lack of control of intensity of the program.	Judo appears to increase lean mass and improve cardiopulmonary fitness in adolescents in a controlled program. No effect was made in BMI.
Roh, 2020	To evaluate the effects of taekwondo on	Randomized control study	20 children and adolescents aged 11-13 in	Control group received no physical intervention, were asked to log all foods.	Taekwondo was effective for a reduction in weight by 3kg with statistically significant	Quality Appraisal 9/11	Taekwondo appears to have a beneficial effect on BMI and weight reduction in children 11-13. Taekwondo also

Author	Purpose	Design	Sample/ Setting	Methods	Findings	Quality Appraisal/ Limitations	Conclusions/ Application
	oxidative stress markers and myokine in obese children		Korea. Average age was 12.55 years. 14 boys and 6 girls participated	Experimental group was placed in a 60 minute Taekwondo class 5 times per week for 16 weeks. Measurements were taken both pre and post intervention. Measurement of height, weight, and BMI. Cardiovascular fitness via VO2max and muscular strength were tested with grip and leg strength testing.	reduction in BMI with a CI of 99%. No effect was had on cardiovascular fitness for the intervention group.		improved muscular strength and flexibility, but did not demonstrate an improvement in cardiovascular fitness.
Pinto-Escalona, 2021	To evaluate a karate based Physical Education program through school.	Randomized control study	721. participants were spread over 5 European countries. Control and intervention groups	2 hours per week for 1 year. The intervention group did a karate program, while the control group continued normal physical education classes. They observed cardiovascular	The intervention group outperformed the control group in every area of physical fitness, flexibility, and balance. A difference of 0.53 in comparison to	Quality appraisal 8/11 Limitations included differences in baseline activity level between nations. Had a lack of blinding in the groups. Had a	Karate for PE outperformed standard PE classes over 5 countries in Europe. An intervention like this could be useful in our country given some socioeconomic obstacles to entry into a martial arts program. This study did not

Author	Purpose	Design	Sample/ Setting	Methods	Findings	Quality Appraisal/ Limitations	Conclusions/ Application
			had similar anthropomorphic characteristics and physical activity level. Average age was 7.4 years. Percentage of girls 48%	fitness, strength, academic achievements, and psychological assessments.	control with a P-value of 0.001	diverse PE curriculum across different nations. Did not only observe obese children.	specifically observe only obese children. Intervention did significantly outperform traditional PE but cost for instructor training may not be feasible.
Saraiva , 2021	Analyze the effects of 16 weeks of Muay Thai training on obese adolescents	Quasi-experimental	33 obese youth in Brazil. 18 in intervention 15 in control group, ages 10-17. The average age was 12.6 years. 21 boys and 12 girls	The intervention group was put in an 1.5 hour MT class 3 days per week on nonconsecutive days. It included fight sparring and sought to maintain moderate to high intensity for the duration of the class. The control group was excluded from training. Both	Reduction in body fat of statistical significance in MT group (delta of -2.8%) but not in control. Mt group gained lean muscle mass versus control with a delta of 2.81 in Maui Thai group versus 0.27 in control with a p value of 0.033.	Quality Appraisal 7/11 No randomization, Small sample size. Lack of cardiovascular fitness testing.	MT decreases body fat particularly around the abdomen. Increased lean muscle mass. Did not provide analysis past ending of study on how many continued MT. Did not evaluate metabolic markers. It did however look more than other studies at body fat and lean muscle mass.

Author	Purpose	Design	Sample/ Setting	Methods	Findings	Quality Appraisal/ Limitations	Conclusions/ Application
Chainok, 2022	Compares resistance training and aerobic training with muay thai high intensity interval training on obese adolescents	Randomized control study	24 obese females in Thailand	<p>were participant .</p> <p>groups were asked to document food intake and to not change normal patterns of eating. Two groups were randomly selected. The control group did a combination of weightlifting and aerobic training. The muay Thai group did a HIIT training session of punches, kicks, grappling, kneeing, and elbowing. The research team measured body composition, flexibility, muscular strength, and muscular endurance before and after 8 weeks. Muay Thai led to greater muscular endurance relative to the control.</p>	Both the control group and muay Thai groups had significant increases in muscular strength and endurance. There was an overall effect on body composition, but no significant effect on body fat.	<p>Quality Appraisal 6/11</p> <p>Limited sample size, limited duration of study, they estimated after completing the study 12 weeks would have been more appropriate. The training volume for the control group was suboptimal in the initial weeks. Diet was not controlled for during the study. This only studied female participants.</p>	This showed muay Thai to be a legitimate means of improving body composition, losing body fat, and increasing muscular endurance. There should be some caution taken when applying this to the whole population given the limitations of the study.

Author	Purpose	Design	Sample/ Setting	Methods	Findings	Quality Appraisal/ Limitations	Conclusions/ Application
Nyrc, 2023	To evaluate the efficacy of taekwondo vs inactive teens. Secondary purpose to correlate BMI of the children with that of their parents.	Quasi-experimental	135 participants, 45 were the adolescents in the trial, but 90 parents were evaluated for BMI and other measurements. Setting was general population of Poland	The intervention group was selected from families that were already training in Taekwondo. The control group was randomly selected from the remaining respondents. The children were put through a physical fitness test as well as anthropomorphic testing. Parents self-reported height and weight, BMI was calculated from data.	No significant difference in BMI was appreciated between intervention and control group. There was a significant difference in body composition. The study failed to conclude a definite relationship between parents BMI and children's BMI.	Quality rating 9/11 The study did not adjust for individuals that just began training. Using parents self reported height and weight as well as a lack of anthropomorphic analysis of parents body composition.	No major difference appreciated in BMI, however the physical fitness was higher in the Taekwondo group. Further data needs to be gathered to make any assertions on parental BMI is influential or a predictor of increased physical activity.

Author	Purpose	Design	Sample/ Setting	Methods	Findings	Quality Appraisal/ Limitations	Conclusions/ Application
de Souza, 2022	Evaluate cardiometabolic, oxidative markers, and inflammation in overweight and obese adolescents.	Randomized controlled study	70 adolescents 12-17. Setting in Brazil	Control group received 1 weekly nutritional and psychological intervention. Intervention group received the same nutritional and psychological intervention as well as 3 times per week of karate training for 1 hour per session.	Intervention showed reduction in resting HR, low density lipids, and triglycerides.	Quality appraisal 8/11 Limitations include self-reporting of effort. Had several drop out of study.	Karate is an option for increasing cardiovascular fitness and health markers.

Abbreviations (*in alphabetical order*): BFP= body fat percentage; BMI=body mass index; BP=blood pressure; CI=Confidence interval; CPF=cardiopulmonary fitness; CPT=cardiopulmonary testing; PRN=as needed; RCT=randomized controlled trial; WC=waist circumference.