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Systematic Review and meta-analysis

EFECTO DE LOS DEPORTES DE COMBATE EN LA COMPOSICIÓN CORPORAL DE NIÑOS Y ADOLESCENTES CON SOBREPESO Y OBESIDAD: UNA REVISIÓN SISTEMÁTICA Y METAANÁLISIS.

EFFECT OF COMBAT SPORTS ON THE BODY COMPOSITION OF OVERWEIGHT AND OBESITY CHILDREN AND ADOLESCENTS: A SYSTEMATIC REVIEW AND META-ANALYSIS

Santo, L. A. E.[1], Grabalos, L.[1], Santos, I. A.[2,3], Bertochi G. F. A.[1], Vieira-Souza, L. M.[3,4], Mota, G. R.[1], Teixeira-Coelho, F. T.[1], Oliveira, D. C. X.[1]

[1] *Exercise Science Health and Human Performance Research Group, Department of Sport Sciences, Federal University of Triângulo Mineiro, Uberaba/MG, Brazil;*

[2]. *Postgraduate Program in Rehabilitation and Functional Performance, University of São Paulo, Ribeirão Preto, São Paulo, Brazil;*

[3]. *Center for Studies and Research in Physical Activity, Health and Sport, Brazil;*

[4]. *Department of Human Body and Movement, State University of Minas Gerais-UEMG, Passos, Minas Gerais, Brazil;*

Correspondence to:
Donizete Cícero Xavier de Oliveira
Departament of Sports Science
Professor Aluízio Rosa Prata Research Center
Vigário Carlos Street, 100 – 4th floor, 434
Abadia District, Uberaba – MG, Brazil. Zip code: 38025-350
e-mail: donizete.oliveira@uftm.edu.br

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RESUMEN

La obesidad afecta a millones de niños y adolescentes, causando diversos problemas. Por otro lado, los deportes de combate potencialmente generan resultados positivos en algunos parámetros de salud. Este estudio metaanalítico tiene como objetivo verificar si la práctica de deportes de combate tiene un efecto positivo en la composición corporal de adolescentes con sobrepeso y obesidad. Se realizó una búsqueda sistemática utilizando el protocolo PRISMA, en las bases de datos PubMed, Embase y Web of Science. La revisión fue registrada en PROSPERO (CRD42023392515). Dos revisores seleccionaron de manera ciega y basados en criterios de elegibilidad (ensayos clínicos aleatorizados, intervención con deportes de combate durante al menos 12 semanas, y con datos de composición corporal de niños y adolescentes con sobrepeso y obesidad), extrajeron los datos y realizaron la evaluación de riesgo de sesgo (RoB 2). Se realizó un metaanálisis utilizando el software Review Manager 5.4. Se incluyeron siete estudios, que abarcaron a 296 participantes con sobrepeso y obesidad, con edades entre 10 y 17 años. Tres estudios se encontraron con taekwondo, un estudio con tai chi y kung fu, capoeira, muay thai y karate. El metaanálisis mostró resultados significativos en el índice de masa corporal (-0,54 kg/m²; IC del 95%: -0,93, -0,15), pero resultados no significativos con respecto al porcentaje de grasa corporal (-0,30%; IC del 95%: -0,79, 0,20), masa magra (0,06 kg; IC del 95%: -0,36, 0,48), masa corporal total (-0,00 kg; IC del 95%: -0,29, 0,29), masa grasa corporal (-0,05 kg; IC del 95%: -0,61, 0,51). Los deportes de combate practicados por adolescentes durante un mínimo de 12 semanas son efectivos para reducir el índice de masa corporal; sin embargo, no fue posible concluir sobre su efectividad para reducir la masa magra corporal, la masa grasa corporal, la masa corporal total y el porcentaje de grasa corporal.

Palabras clave: Artes marciales; Grasa abdominal; Joventud.

ABSTRACT

Obesity affects millions of children and adolescents, causing various problems. Conversely, combat sports potentially yield positive outcomes in some health parameters. This meta-analytical study to verify whether the practice of combat sports has a positive effect on the body composition of overweight and obese adolescents. A systematic search was conducted using the PRISMA protocol, in the PubMed, Embase, and Web of Science databases. The review was registered in PROSPERO (CRD42023392515). Two reviewers selected, blindly and based on eligibility criteria (randomized clinical trials, intervention with combat sports for at least 12 weeks, and with body composition data of overweight and obese children and adolescents), extracted the data, and performed the risk of bias (RoB 2). Meta-analysis was performed using Review Manager 5.4 Software. Seven studies were included, encompassing 296 overweight and obese participants, aged 10 to 17 years. Three studies were found with taekwondo, one study with tai chi and kung fu, capoeira, muay thai, and karate. The meta-analysis showed significant results in body mass index (-0.54 kg/m²; 95% CI: -0.93, -0.15), but non-significant results regarding percentage of body fat (-0.30%; 95% CI: -0.79, 0.20), lean mass (0.06 kg; 95% CI; -0.36, 0.48), total body mass (-0.00 kg; 95% CI: -0.29, 0.29), fat body mass (-0.05 kg; 95% CI: -0.61, 0.51). Combat sports practiced by adolescents for a minimum of 12 weeks are effective in reducing body mass index; however, it was not possible to conclude their effectiveness in reducing lean body mass, fat body mass, total body mass, and percentage of body fat.

Keywords: Martial arts; Abdominal fat; Youth

Journal of Sport and Health Research 2025, 18(1):1-18

INTRODUCTION

Obesity is a multifactorial syndrome affecting different age groups, and there has been a constant increase in the prevalence of overweight and obesity in children and adolescents, considered a public health problem (Afshin et al., 2017). According to the World Health Organization (WHO), over 390 million children and adolescents aged 5 to 19 were classified as overweight or obese worldwide in 2022 (WHO, 2024). Moreover, overweight and obesity in childhood and adolescence seem to negatively interfere with physical, psychological, cognitive development, and provoke physiological changes during puberty (Lakshman et al., 2012).

Sedentary behavior, identified as a facilitator for overweight and obesity, is on the rise among children and adolescents worldwide (Wyszyńska et al., 2020). A study by Guthold et al. (2020) surveyed 1.6 million students aged 11 to 17 across 144 countries, revealing that 81% of adolescents reported insufficient levels of physical activity. This finding is consistent with the global trend of low physical activity among children and adolescents, as highlighted in the Global Matrix 4.0 Report Cards, where the global average rating for physical activity indicated that only 27% to 33% of children and adolescents are meeting the recommended amount of moderate to vigorous physical activity. In Brazil, sedentary behavior among 9th-grade students increased from 39.4% in 2009 to 61.6% in 2019 (PENSE, 2019).

Adolescence, a pivotal phase for physiological and psychological growth (WHO, 2021), sets the stage for lifelong habits, including attitudes towards physical activity and its health effects (Winpenny et al., 2020). To address sedentary behavior effectively, it's crucial to propose methods that maintain adolescents' adherence to exercise programs or sports (Hills, Andersen, & Byrne, 2011; Rodríguez et al., 2021).

According to the WHO guidelines on physical activity and sedentary behavior (2020), children and adolescents aged 5 to 17 years should engage in at least 60 minutes of daily physical activity of moderate to vigorous intensity. It is recommended that this activity primarily be aerobic, such as running, cycling, or swimming. Additionally, it is advised that, at least three times per week, activities that strengthen muscles and bones be included, such as resistance exercises, running, or activities that involve jumping. These guidelines aim to promote physical health, strengthen muscles and bones, and contribute to mental well-being while preventing the development of chronic diseases such as obesity, type 2 diabetes, and cardiovascular diseases.

Regarding sports, there is evidence of waist circumference reduction, a measure of increased cardiovascular risk, observed with football practice (Nunes et al., 2021). The study by Trajković, et al. (2021) showed positive effects on the body composition of overweight girls through volleyball practice in after-school programs.

Some studies have presented positive results in the body composition of children and adolescents, such as increased lean mass, reduced body mass index, and decreased percentage of body fat, using aerobic and concurrent exercises (Monteiro et al., 2015; Seo et al., 2019; Meng et al., 2022; Wang et al., 2022). Kelley et al. (2017) found that combined aerobic and strength exercises are more effective in reducing BMI in pediatric populations compared to aerobic exercise alone.

Combat sports are gaining research interest, but findings remain inconclusive. Saraiva et al. (2021) found increased lean mass and a trend towards reduced fat mass after 16 weeks of Muay Thai. Conversely, Souza et al. (2021), observed reduced inflammatory markers but no significant body composition changes after 12 weeks of karate among overweight adolescents.

Combat sports, known for their high-intensity nature, offer an enjoyable option for children and adolescents (ACSM, 2015), addressing sedentary behavior effectively (Hills, Andersen, & Byrne, 2011). However, their impact on body composition parameters remains unclear. Therefore, this systematic review with meta-analysis aims to evaluate whether engaging in combat sports positively impacts the body composition of overweight and obese adolescents. Furthermore, it is expected to find benefits in the body composition of overweight and obese adolescents through the practice of combat sports.

METHODS

The methodology of this systematic review adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Journal of Sport and Health Research 2025, 18(1):1-18

(PRISMA) statement, as shown in Figure 1. Additionally, the review followed the Cochrane Handbook for Systematic Reviews of Interventions and the Cochrane Methodological Expectations for Intervention Reviews (Higgins et al., 2023) to ensure a rigorous search process and enhance the validity and reliability of the study. Furthermore, when possible, studies listed in the reference list of the selected papers were found, we analysed the possibility of inclusion, including in this system, the so-called “gray literature”, such as these dissertations, among others. The risk of bias was assessed using the RoB 2 tool, a validated method for randomized controlled trials (RCTs), which was implemented to evaluate potential bias across the included studies.

The study protocol was prospectively registered with PROSPERO under the identifier CRD42023392515. Notably, only one similar study protocol was identified in previously published literature; however, it included broader age groups rather than focusing exclusively on children and adolescents, which is the target population of this review. The Review Manager 5.4 software was used to conduct the meta-analysis, applying the inverse variance method to synthesize the results (Figure 2).

Review question
The review questions adopted were defined using PICOS model:
Population: adolescents aged 10 – 17 years.
Intervention: combat sports.
Comparators: overweight and/or obese.
Outcomes: BMI ≥ 85th percentile and/or BMI ≥ 95th percentile.
Study Design (“S” in PICOS): Randomized Controlled Trials (RCTs).

Eligibility criteria
The following eligibility criteria were adopted: (1) randomized clinical trials; (2) studies published in English; (3) studies focusing on combat sports themes; (4) participants aged between 10 and 17 years old, overweight and/or obese (BMI ≥ 85th percentile and/or BMI ≥ 95th percentile); (5) intervention duration of 12 weeks or more; (6) outcome measures on body composition (fat body mass, lean body mass, total body mass, and percentage of body fat) or BMI. The exclusion criteria include studies with participants outside the defined age range (10-17 years), interventions lasting less than 12 weeks, and studies not reporting detailed body composition data.

Search strategy
The electronic search was conducted across three different databases: PubMed, Embase, and Web of Science. Whenever a potentially eligible article was found in the references of the included articles, it was subjected to verification for possible inclusion in the present study, as well theses, dissertations or other eligible studies. Each database was last searched on January 30, 2022, ensuring that the review reflects the most current evidence available at the time of the search.
The descriptors were included in the databases using advanced searches, with the insertion of Boolean operators for combining the descriptors. The descriptors used in the search were: "Combat sport", "judo", "karate", "jujitsu", "Brazilian jiu-jitsu", "Jiu-jitsu", "taekwondo", "tae kwon do", "kung fu", "Gong fu", "mixed martial arts", "sambo", "krav maga", "karate do", "Ultimate Fighting", "Body composition", "body fat distribution", "body fat patterning", "adiposity", "Abdominal fat", "abdominal adipose tissue", obesity, "skinfold thickness", "body weight", "abdominal obesity", "central obesity", "visceral obesity"; "Adolescent", "adolescence", "teen", "Youth", "adolescent female", "female adolescent", "adolescent male".

Study selection and data extraction
The studies were imported into a systematic review screening software called Rayyan. Three reviewers participated in the screening process, with two independent reviewers (LG and LA) conducting the analysis of titles and abstracts, while a third reviewer (DO) was responsible for resolving decisions in case of discrepancies during the selection.
After the selection of articles, the extracted information included: authors, publication date, language, sample size, age, body composition (lean mass and fat mass), body mass index, intervention, control, and outcomes.

Risk of bias analysis
To assess the risk of bias, the Cochrane tool for randomized controlled trials (RoB 2) was used, which comprises five specific domains. For each domain, there are outcomes covering "High risk," "Some concerns," and "Low risk." Two independent

Journal of Sport and Health Research 2025, 18(1):1-18

researchers (LA and GB) evaluated each topic for each domain, and a third researcher (DO) was responsible for resolving any potential discrepancies.

Quality of Evidence Assessment

The quality of evidence was assessed using the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) methodology, which considers risk of bias, inconsistency, imprecision, indirectness, and publication bias. The final evidence grading was assigned as high, moderate, low, or very low, reflecting the level of confidence in the results and providing guidance for clinical practice and future research.

Data analysis

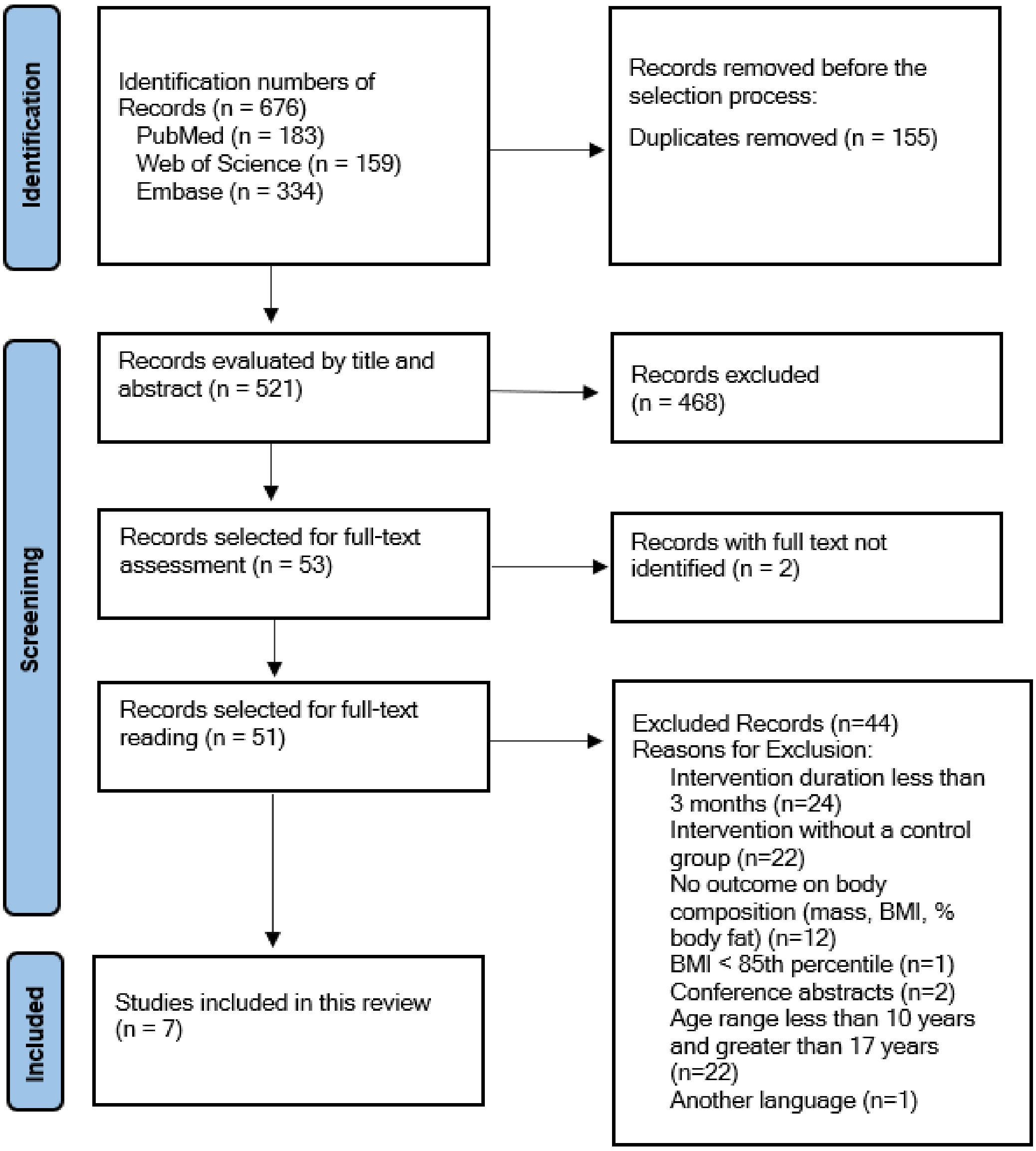
The data were analyzed and presented using a narrative synthesis approach. The publication year, study design, country of origin, types of combat sports selected for intervention, sample characteristics, outcome measures, and treatments applied to the intervention groups were examined. Overall effect sizes for each outcome were determined using meta-analytic approaches when at least 2 studies assessed the specific outcome. Review Manager 5 software (Version 5.4) was used, and random-effects models were applied.

Meta-analyses were conducted to examine the effects of combat sports compared to control groups. Mean difference standard deviation (SD) with 95% confidence intervals (CI) were reported (Figure 2). Heterogeneity was determined following Cochrane Guidelines: I^2; from 0% to 40% represents low heterogeneity; 30% to 60% represents moderate heterogeneity; 50% to 75% represents substantial heterogeneity; 75% to 100% is considered high heterogeneity. Attempts via email were made to obtain missing data from the authors of the studies.

RESULTS

The search in the databases initially yielded 676 studies. Of these, 155 articles were removed as duplicates, leaving 521 articles for title and abstract evaluation. After reviewing the titles and abstracts, 53 studies were selected for full-text reading; however, 2 studies were subsequently removed as the full texts could not be found, even after requesting them from the authors via email. Upon completion of the reading of the 51 studies, it was noted that some did not meet one or more eligibility criteria, with a total of 44 studies removed for the following reasons: intervention duration less than 3 months (n=24), intervention without a control group (n=22), intervention without outcome measures on body composition (total body mass, lean body mass, fat body mass, BMI, % body fat) (n=12), conference abstracts (n=2), age range less than 10 years and greater than 19 years (n=22), BMI < 85th percentile (n=1), language other than English or Portuguese (n=1), with some studies being excluded for meeting two or more exclusion criteria. Seven randomized clinical trials were included in this systematic review, published between 2009 and 2021 (Figure 1).

Figure 1. Organization of literature searches. Indication of studies via database and records:



Study characteristics

Three studies (42.9%) were conducted in Brazil, three studies (42.9%) in South Korea, and one study (14.3%) in Australia. The most analyzed modality in this study was taekwondo, with three studies. The other studies used various modalities, such as tai chi, kung fu, capoeira, muay thai, and karate. The analysis included 296 physically inactive adolescents, with sample sizes ranging from 20 to 138, with a mean of 21.14 ± 20.71 participants. The majority were girls (n = 187), with a total sample mean age of 12.4 ± 1.67 years. Regarding participants' experience in the modalities, two studies (Jung et al., 2018; Jung et al., 2016) reported that participants did not practice taekwondo for at least 2 years, one study (Roh et al., 2020) reported that participants had no experience in taekwondo, three studies (Souza et al., 2021; Saraiva et al., 2021; Nogueira et al., 2014) did not inform

Journal of Sport and Health Research 2025, 18(1):1-18

whether participants had previously practiced the modality, and one study (Tsang et al., 2009) stated that participants had no experience with any combat sport.

Body mass index (BMI)

Among the 7 studies in this review, five studies (71.4%) assessed the BMI of the participants, but only 3 studies (Jung et al., 2016; Jung et al., 2018; Roh et al., 2020) (42.9%) found a significant difference between the trained group (TG) and the control group (CG).

In the study by Jung et al. (2016), the outcomes for the TG indicated a significant reduction in BMI ($p < 0.05$) compared to the CG. In another study by Jung et al. (2018), there was again a significant reduction in BMI ($p < 0.01$) in the TG, while the CG did not show a significant reduction. The outcomes found by Roh et al. (2020) also show a significant reduction in the TG ($p < 0.001$), which was not observed in the CG (Table 1).

The meta-analysis included the five studies that had outcome data regarding the intervention of martial arts on participants' BMI (Figure 2). The meta-analysis showed significant results favoring combat sports interventions for BMI reduction of -0.54 kg/m² (95% CI: -0.93, -0.15; $I^2 = 11\%$), $p = 0.006$ and low heterogeneity. According to the GRADE framework, the quality of evidence for BMI outcomes was rated as high, indicating strong confidence in the findings with minimal risk of bias or inconsistency among studies (Table 4).

Body fat percentage

Regarding body fat percentage, four articles (Saraiva et al., 2021; Jung et al., 2018; Souza et al., 2021; Tsang et al., 2009) (57.1%) observed changes in the pre- and post-intervention period. Three other articles did not collect data on the percentage of body fat of the sample.

Among the studies that assessed body fat percentage, two (28.6%) found significant reductions when comparing the intervention and control groups. The study by Saraiva et al. (2021) found a significant reduction in body fat percentage in the TG compared to the CG ($p = 0.019$). The research by Jung et al. (2018) demonstrated significant reductions after the intervention period, both in the TG ($p < 0.01$) and in the CG ($p < 0.05$) (Table 1).

Additionally, two studies (28.6%) did not find significant reductions in either group. The results of Souza et al. (2021) showed that after the intervention, the TG and CG did not show significant changes in body composition ($p = 0.185$). Tsang et al. (2009) also obtained non-significant results between the TG and CG both in the time effect ($p = 0.30$) and in the interaction of time and group ($p = 0.54$) (Table 1).

After the meta-analysis of the 4 studies, it was found that there was no tendency for the experimental group practicing combat sports to reduce body fat percentage, resulting in -0.30% (95% CI: -0.79, 0.20; $I^2 = 40\%$). Statistically significant values were also not observed ($p = 0.24$) (Figure 2). Under the GRADE assessment, the quality of evidence for body fat percentage outcomes was rated as very low, primarily due to serious concerns about risk of bias, inconsistency, and imprecision (Table 4).

Lean body mass

Among the studies included in this review, four (57.1%) measured lean body mass. Of these, three studies (Saraiva et al., 2021; Jung et al., 2018; Tsang et al., 2009) (42.9%) observed significant differences between the groups.

Saraiva et al. (2021) observed a considerable increase in lean body mass in the TG after the intervention with time interaction ($p = 0.033$), while the CG did not show significant results. The study by Jung et al. (2018) showed a significant increase ($p < 0.05$) in lean body mass in the CG after the intervention period, while the TG did not show significant differences. The results of Tsang et al. (2009) showed an increase in lean body mass of participants in both groups (TG and CG) regarding the time effect ($p < 0.0001$), with no statistical differences between them (Table 2).

Only one study (14.2%) did not find statistically significant differences between the groups post-intervention. Nogueira et al. (2014) did not observe a difference between the TG and CG (Table 2).

The outcomes of the four studies (57.1%) on lean body mass are shown in Figure 2. The meta-analysis showed no significant difference regarding lean body mass, with 0.06 kg (95% CI: -0.36, 0.48; $I^2 = 0\%$) with $p = 0.78$ and low heterogeneity. Using the GRADE methodology, the evidence for lean body mass outcomes was classified as very low, reflecting very serious concerns regarding risk of bias and imprecision (Table 4).

Journal of Sport and Health Research 2025, 18(1):1-18

Total body mass

All studies found in this review (100%) collected data on participants' body mass.

Among the studies that showed pre- and post-intervention outcomes regarding body mass, four studies (Roh et al., 2020; Jung et al., 2018; Jung et al., 2016; Saraiva et al., 2021) (57.1%) obtained statistically significant results when comparing the intervention and control groups. The study by Roh et al. (2020) showed a significant reduction in body mass among intervention participants ($p < 0.05$) and in the time interaction ($p < 0.001$), while the control did not have statistically significant changes. Jung et al. (2018) also showed a significant reduction in body mass for the TG ($p < 0.01$) and also concerning time ($p < 0.01$), as well as non-significant results for the CG. Similarly, in the study by Jung et al. (2016), significant reductions in total body mass were found for the TG ($p < 0.01$) and non-significant for the CG. The study by Saraiva et al. (2021) showed a difference between the groups, with an increase in body mass of GT participants ($p = 0.029$), with no significant change in the CG (Table 1).

Two studies (28.6%) presented statistically significant results when compared to time but not significant when compared between intervention and control groups. Tsang et al. (2009) showed that after the intervention period, there was an increase in total body mass in both TG and CG ($p = 0.0003$), as well as the outcome of Nogueira et al. (2014), which observed an increase in body mass in both TG and CG with $p \leq 0.05$ (Table 1).

Finally, one study (14.2%) did not obtain any statistically significant change in both groups. The study by Souza et al. (2021) observed similar results for TG and CG (Table 1).

Seven studies (100%) evaluated the outcome of combat sports interventions regarding total body mass (Figure 2). The meta-analysis did not show significant benefits of this practice on the groups after the experimental period, reporting -0.00 kg (95% CI: -0.29, 0.29; $I^2 = 25\%$), $p = 0.98$ and low heterogeneity. According to the GRADE framework, the quality of evidence for total body mass outcomes was rated as very low due to very serious risk of bias and imprecision (Table 4).

Body fat mass

Four studies (57.1%) assessed participants' body fat mass, but only two (Saraiva et al., 2021; Jung et al., 2018) (28.6%) found statistically significant results.

Saraiva et al. (2021) showed a reduction in body fat mass among the groups ($p = 0.009$) after the intervention period. The results of Jung et al. (2018) also showed a reduction in body fat mass in the TG ($p < 0.01$), while there were no significant changes in the CG (Table 2).

Two articles (28.6%) found no post-intervention differences. The study by Nogueira et al. (2014) did not observe significant differences between the TG and the CG. Tsang et al. (2009) also did not show significant post-intervention changes in the TG or the CG (Table 2).

After the meta-analysis of the 4 studies, it was not possible to observe a trend towards a reduction in body fat mass, with -0.05 kg (95% CI: -0.61, 0.51; $I^2 = 41\%$). Statistically significant values were also not observed, with $p = 0.87$ and moderate heterogeneity (Figure 2). Based on the GRADE criteria, the evidence quality for fat mass outcomes was determined to be very low, with very serious concerns about risk of bias and imprecision, as well as serious inconsistency (Table 4).

Journal of Sport and Health Research 2025, 18(1):1-18

Table 1. Comparison of body composition parameters between groups at pre and post-intervention moments. Values in mean (standard deviation).

Studies/ Intervention	Groups	BMI		TBM		%BF	
		Before	After	Before	After	Before	After
Tsang *et al*., 2009 Kung fu/Tai chi	Intervention	32.1 (6.7)	32.7 (7.8)	84.9 (24,2)	87.2 (25.4) [b]	44.6 (6.6)	43.1 (7.6)
	Control	34.0 (7.0)	34.2 (7.2)	87.2 (25.4)	93.6 (25.5) [b]	47.7 (5.3)	47.4 (5.6)
Nogueira *et al*., 2014 Capoeira	Intervention	NA	NA	39,3 (9.4)	43,0 (10.2) [b]	NA	NA
	Control	NA	NA	37,2 (7.2)	39,3 (9.4) [b]	NA	NA
Jung *et al*., 2016 Taekwondo	Intervention	28.9 (2.38)	27,0 (3.03) [a]	84,6 (13.91)	80.7 (14.88) [a]	NA	NA
	Control	30.6 (1.78)	30.2 (1.64)	86.4 (10.09)	86.9 (8.91)	NA	NA
Jung *et al*., 2018 Taekwondo	Intervention	29.1 (2.32)	27.2 (3.06) [a]	86.8 (12.38)	82.6 (13.95) [ab]	33.4 (3.92)	30.1 (5.68) [b]
	Control	29.7 (1.29)	29.5 (1.31)	84.6 (13.95)	85.7 (7.88)	35.7 (4.94)	34.3 (4.77) [b]
Saraiva *et al*., 2021 Muay Thai	Intervention	NA	NA	71.21 (19.02)	71.94 (18.89) [a]	44.67 (6.41)	41.88 (6.57) [a]
	Control	NA	NA	68.52 (17.73)	69.18 (17.45)	39.90 (5.65)	39.52 (6.02)
Roh *et al*., 2020 Taekwondo	Intervention	24.91 (1.90)	23.59 (1.84) [a]	58.34 (7.13)	55.99 (6.53) [ab]	NA	NA
	Control	23.74 (1.43)	23.82 (1.42)	54.99 (7.06)	55.34 (6.51)	NA	NA
Souza *et al*., 2021 Karate	Intervention	26.57 (2.90)	26,42 (2.84)	71.04 (10.24)	71.69 (11.81)	35.10 (8.34)	34.31 (9.31)
	Control	27.05 (3.15)	27,76 (3.55)	74.35 (10.58)	75.64 (13.35)	35.89 (8.70)	37.92 (7.86)

"a" Significant difference between the intervention group and control group; "b" Significant difference between pre and post intervention; $p < 0.05$; BMI: Body Mass Index; TBM: Total Body Mass; %BF: Body Fat Percentage. NA = Variable not analyzed.

Table 2. Comparison of body composition parameters between groups at pre and post-intervention moments. Values in mean (standard deviation).

Studies/ Intervention	Groups	LBM		FM	
		Before	After	Before	After
Tsang *et al*., 2009 Kung fu/Tai chi	Intervention	44.5 (9.8)	46.8 (10.5) [b]	37.5 (15.0)	37.4 (15,7)
	Control	45.0 (10.3)	46.8 (10.2) [b]	42.9(15.4)	44.2 (15.6)
Nogueira *et al*., 2014 Capoeira	Intervention	23.44 (5.27)	27.08 (6.19)	15.95 (5.32)	17.16 (6.46)
	Control	23.27 (3.50)	25.40 (4.93)	13.57 (3.88)	13.59 (3.68)
Jung *et al*., 2016 Taekwondo	Intervention	NA	NA	NA	NA
	Control	NA	NA	NA	NA
Jung *et al*., 2018 Taekwondo	Intervention	54.6 (9.18)	54.3 (9.03)	28.4 (4.34)	24.8 (6.52) [a]
	Control	51.4 (8.82)	53.3 (7.70) [a]	29.4 (2.68)	28.7 (3.19)
Saraiva *et al*., 2021 Muay Thai	Intervention	36.28 (8.71)	38.77 (9.54) [b]	32.38 (11.47)	30.65 (10.92) [a]
	Control	38.59 (9.14)	39.19 (9.53)	27.70 (9.71)	27.63 (9.42)
Roh *et al*., 2020 Taekwondo	Intervention	NA	NA	NA	NA
	Control	NA	NA	NA	NA
Souza *et al*., 2021 Karate	Intervention	NA	NA	NA	NA
	Control	NA	NA	NA	NA

"a" Significant difference between the intervention group and control group; "b" Significant difference pre and post-intervention; $p < 0.05$; LBM: Lean Body Mass; FM: Fat Mass.

Table 3. Characteristics of studies with combat sports interventions.

Author/year	Sex and age (N)	Duration Frequency Time	Intervention TG/CG	Tests	Country	Results
Tsang *et al.* (2009)	M/F TG (11) 13.4±2.0; CG (8) 13.1±1.6;	6 months 3x p/week 60 min	Kung Fu/ GC (Tai chi)	%BF FBM TBM LBM BMI	Australia	**%BF:** GT↔GC **FBM**: GT↔ GC **TBM**: GT ↑; GC ↑ **LBM**: GT↑; GC↑ **BMI**: GT↔GC
Nogueira *et al.* (2014)	F TG (71) 11.3±0.6; CG (67) 11.4±0.6;	9 months 3x p/week 10 min.	Capoeira	FBM TBF LBM	Brazil	**FBM**: GT↔GC **TBM:**GT↑; GC↑ **LBM**: GT↔GC
Jung *et al.* (2016)	M TG (12); CG (11); 14.0±0.9	4 months 3x p/week 60 min	Taekwondo	TBM BMI	South Korea	**TBM:** GT↓ **BMI:** GT↓
Jung *et al.* (2018)	M TG (9) 13.9±0.94; CG (11) 13.9±0.60;	4 months 3x p/week 60 min	Taekwondo	%BF FBM TBM LBM BMI	South Korea	**%BF**:GT↓; GC↓ **FBM**: GT↓ **TBM**: GT↓ **LBM**: GC↑ **BMI**: GT↓
Saraiva *et al.* (2021)	M/F TG (18) 12.61±2.09; CG (15) 12.07±2.21;	4 months 3x p/week 70 min	Muay Thai	%BF FBM TBM LBM	Brazil	**%BF**:GT ↓ **FBM**:GT↓ **TBM**: GT↑ **LBM**: GT↑
Roh *et al.* (2020)	M/F TG (10) 12.60±0.52; CG (10) 12.50±0.53;	4 Months 5x p/week 60 min	Taekwondo	TBM BMI	South Korea	**TBM**: GT↓ **BMI**: GT↓
Souza *et al.* (2021)	M/F TG (22) 14.32±1.28; CG (20) 14.50±1.39;	3 months 1x p/week 60 min	Carate	%BF TBM BMI	Brazil	**%BF**: GT↔GC **TBM**: GT↔GC **BMI**:GT↔GC

CG: control group; TG: trained group; %BF: percentage of body fat; TBM: total body mass; FBM: fat body mass; LBM: lean body mass; BMI: body mass index; N: sample; F: female; M: male; ±: standard deviation; "↔": no difference between groups;"↓"decrease;"↑"increase.

Journal of Sport and Health Research 2025, 18(1):1-18

Table 4. Assessment of evidence quality using the GRADE framework

Certainty assessment							Summary of results					Importance
							Nº participants		Effect		Certainty	
Studies	Design	Methodological Limitations	Inconsistencie	Indirect Evidence	Imprecision	Other Considerations	Judo	Control	Relative (95% IC)	Absolute (95% IC)		
Total body mass												
7	RCT	Very Serious	Not serious inconsistency	Not serious	Serious	None	156	140	-	SMD 0 (0.29; 0.29)	⊕◯◯◯ Very low[a,b]	Important
Fat body mass												
4	RCT	Very Serious	Serious inconsistency	Not serious	Serious	None	52	38	-	SMD 0.05 (0.61; 0.52)	⊕◯◯◯ Very low[a,b,c]	Important
Lean body mass												
4	RCT	Very Serious	Not serious inconsistency	Not serious	Very Serious	None	52	38	-	SMD 0.06 (0.36; 0.48)	⊕◯◯◯ Very low[a,b,c]	Important
Body fat (%)												
4	RCT	Serious	Serious inconsistency	Not serious	Serious	None	62	52	-	SMD 0.3 (0.79; 0.2)	⊕◯◯◯ Very low[a,b,c]	Important
Body Mass Index (BMI)												
5	RCT	Serious	Not serious inconsistency	Not serious	Not serious	None	67	58	-	SMD 0.54 (0.93; 0.15)	⊕⊕⊕⊕ High[a]	Critical

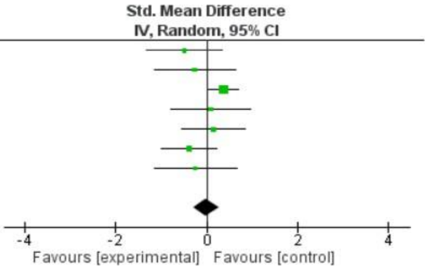
RCT: randomized controlled trial; CI: confidence interval; SMD: standardized mean difference; "a": Meets the PICO; "b": The PRISMA diagram touches the null line, leaning toward the Judo group, downgrade by 1 level. "c": Study heterogeneity, which may be considered moderate, downgrade by 1 level. "d": The PRISMA diagram touches the null line, leaning toward the control group, downgrade by 2 levels.

Journal of Sport and Health Research 2025, 18(1):1-18

Total body mass

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Jung, et al., 2016	80.7	14.88	12	86.9	8.91	11	10.1%	-0.48 [-1.31, 0.35]
Jung, et al., 2018	82.6	13.95	11	85.7	7.88	9	9.1%	-0.25 [-1.14, 0.63]
Nogueira, et al., 2014	43	10.2	71	39.3	9.4	67	32.8%	0.37 [0.04, 0.71]
Roh,et al., 2020	55.99	6.53	10	55.34	6.51	10	9.2%	0.10 [-0.78, 0.97]
Saraiva, et al., 2021	71.94	18.89	18	69.18	17.45	15	13.7%	0.15 [-0.54, 0.83]
Souza, et al., 2021	71.04	10.24	22	75.64	13.35	20	16.3%	-0.38 [-0.99, 0.23]
Tsang, et al., 2009	87.2	25.4	12	93.6	25.5	8	8.8%	-0.24 [-1.14, 0.66]
Total (95% CI)			**156**			**140**	**100.0%**	**-0.00 [-0.29, 0.29]**

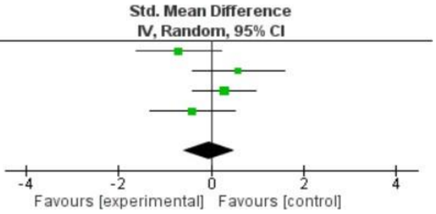
Heterogeneity: Tau² = 0.04; Chi² = 7.96, df = 6 (P = 0.24); I² = 25%
Test for overall effect: Z = 0.02 (P = 0.98)



Fat body mass

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Jung, et al., 2018	24.8	6.52	11	28.7	3.19	9	23.6%	-0.70 [-1.62, 0.21]
Nogueira, et al., 2014	17.16	6.46	12	13.59	3.68	6	20.9%	0.59 [-0.41, 1.60]
Saraiva, et al., 2021	30.65	10.92	18	27.63	9.42	15	32.2%	0.29 [-0.40, 0.98]
Tsang, et al., 2009	37.4	15.7	11	44.2	15.6	8	23.3%	-0.41 [-1.34, 0.51]
Total (95% CI)			**52**			**38**	**100.0%**	**-0.05 [-0.61, 0.52]**

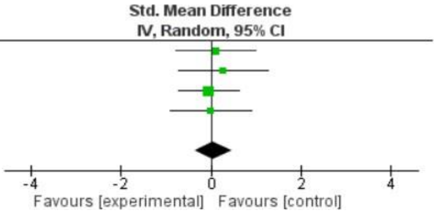
Heterogeneity: Tau² = 0.13; Chi² = 5.05, df = 3 (P = 0.17); I² = 41%
Test for overall effect: Z = 0.16 (P = 0.87)



Lean body mass

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Jung, et al., 2018	54.3	9.03	11	53.3	7.7	9	22.8%	0.11 [-0.77, 0.99]
Nogueira, et al., 2014	27.08	6.19	12	25.4	4.93	6	18.2%	0.27 [-0.71, 1.26]
Saraiva, et al., 2021	38.77	9.54	18	39.19	9.53	15	37.7%	-0.04 [-0.73, 0.64]
Tsang, et al., 2009	46.8	10.5	11	46.8	10.2	8	21.3%	0.00 [-0.91, 0.91]
Total (95% CI)			**52**			**38**	**100.0%**	**0.06 [-0.36, 0.48]**

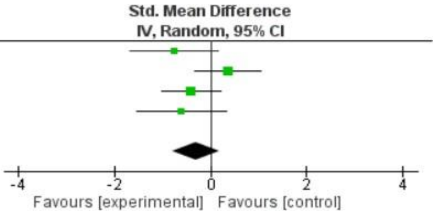
Heterogeneity: Tau² = 0.00; Chi² = 0.30, df = 3 (P = 0.96); I² = 0%
Test for overall effect: Z = 0.28 (P = 0.78)



Body fat percentage

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Jung, et al., 2018	30.1	5.68	11	34.3	4.77	9	20.0%	-0.76 [-1.68, 0.16]
Saraiva, et al., 2021	41.88	6.57	18	39.52	6.02	15	28.4%	0.36 [-0.33, 1.06]
Souza, et al., 2021	34.31	9.31	22	37.92	7.86	20	32.2%	-0.41 [-1.02, 0.20]
Tsang, et al., 2009	43.1	7.6	11	47.4	5.6	8	19.5%	-0.60 [-1.54, 0.34]
Total (95% CI)			**62**			**52**	**100.0%**	**-0.30 [-0.79, 0.20]**

Heterogeneity: Tau² = 0.10; Chi² = 4.99, df = 3 (P = 0.17); I² = 40%
Test for overall effect: Z = 1.17 (P = 0.24)



Body mass index (BMI)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Jung, et al., 2016	27	3.03	12	30.2	1.64	11	16.6%	-1.25 [-2.16, -0.34]
Jung, et al., 2018	27.2	3.06	11	29.5	1.31	9	15.8%	-0.90 [-1.84, 0.03]
Roh,et al., 2020	23.59	1.84	10	23.82	1.42	10	17.7%	-0.13 [-1.01, 0.74]
Souza, et al., 2021	26.42	2.84	22	27.76	3.55	20	32.9%	-0.41 [-1.02, 0.20]
Tsang, et al., 2009	32.7	7.8	12	34.2	7.2	8	17.0%	-0.19 [-1.09, 0.71]
Total (95% CI)			**67**			**58**	**100.0%**	**-0.54 [-0.93, -0.15]**

Heterogeneity: Tau² = 0.02; Chi² = 4.49, df = 4 (P = 0.34); I² = 11%
Test for overall effect: Z = 2.73 (P = 0.006)

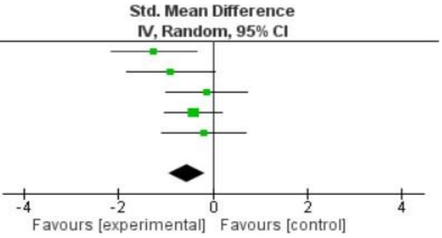


Figure 2. Meta-analysis of the groups separated by each variable addressed.

Journal of Sport and Health Research 2025, 18(1):1-18

Table 5. Risk of Bias by Study

Reference	Domain A	Domain B	Domain C	Domain D	Domain E	Total
Jung *et al*., 2016	Some concerns	Some concerns	High risk	Low risk	Low risk	High risk
Jung *et al*., 2018	Some concerns	Some concerns	High risk	Low risk	Low risk	High risk
Nogueira *et al*., 2014	Some concerns	Some concerns	High risk	Low risk	Low risk	High risk
Roh *et al*., 2020	Some concerns	Some concerns	Low risk	Low risk	Low risk	Some concerns
Saraiva *et al*., 2021	High risk	Some concerns	Low risk	Low risk	Low risk	High risk
Souza *et al*., 2021	Low risk	Some concerns	Low risk	Low risk	Low risk	Some concerns
Tsang *et al*., 2009	Low risk	Some concerns	Low risk	Low risk	Low risk	Some concerns

Domains: "A" Randomization process; "B" Deviations from intended interventions; "C" Lack of outcome data; "D" Outcome measurement method; "E" Selection of reported outcomes; "F" Overall risk of bias.

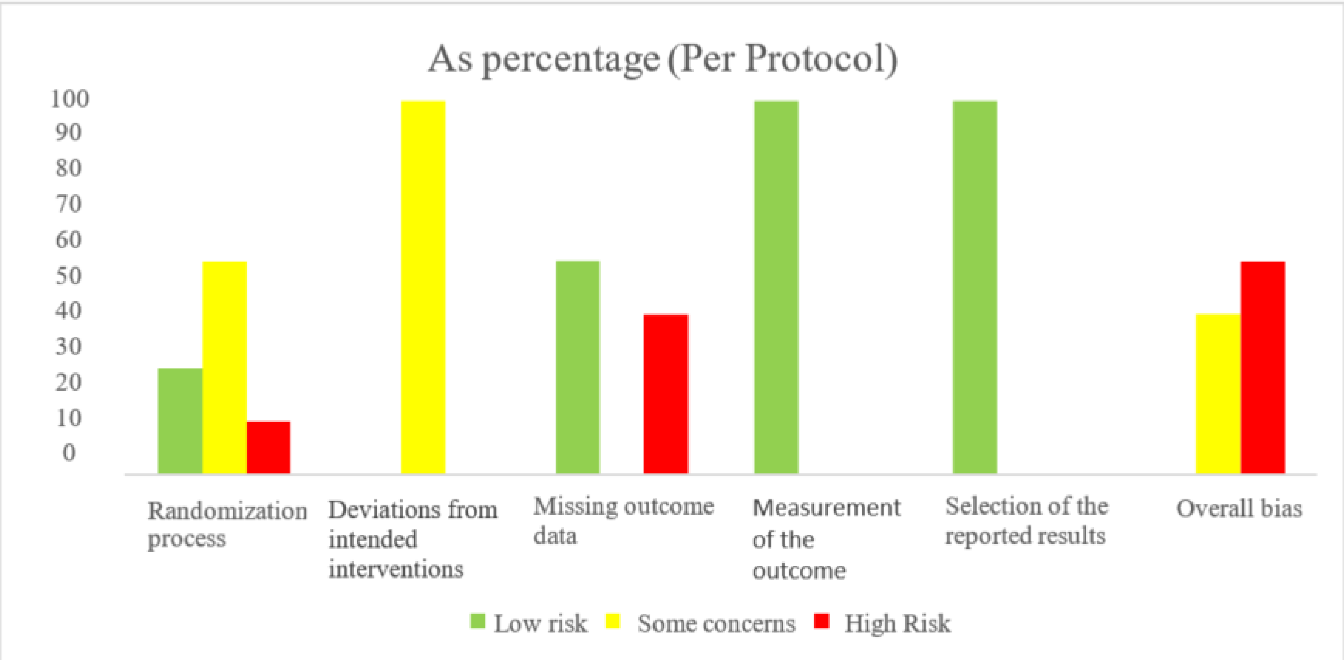


Figure 3. Graph of the risk of bias of the studies.

DISCUSSION

This review and meta-analysis aimed to assess whether combat sports modalities are able of influencing body composition parameters in overweight and obese adolescents. Through meta-analysis, it is possible to identify the potential of combat sports in reducing BMI in the youth population. To our knowledge, this is the first systematic review with meta-analysis focused on the age group of 10 to 17 years, with outcomes on the topics addressed in this study. However, there is a study by Souza et al. (2020), which addresses similar topics but with a greater focus on the adult and elderly age groups.

Regarding BMI, studies such as those conducted by Julian et al. (2022) and Meng et al. (2022) observed improvements in this parameter in adolescents performing high-intensity interval exercises compared to moderate-intensity exercises. These findings may help elucidate the outcomes found in the studies of this review that observed a reduction in this variable, as combat sports are considered high-intensity interval exercises (Jung et al., 2016; Jung et al., 2018; Roh et al., 2020). However, some interventions, such as kung fu/Tai chi and karate, failed to provide high intensities due to long breaks between activities (Tsang et al., 2009; Souza et al., 2021), suggesting that intensity and training programming should be considered when the goal is to promote changes in body composition and nutritional status of participants.

Regarding body composition, more precisely body fat percentage, four out of the seven studies included in the review evaluated this variable, with three of them (Saraiva et al., 2021; Jung et al., 2018; Tsang et al., 2009) using the DEXA method to assess it, while one study (Souza et al., 2021) used bioimpedance. Of these four studies, two found a significant reduction (Saraiva et al., 2021; Jung et al., 2018), while the other two studies (Souza et al., 2021; Tsang et al., 2009) did not identify changes.

The meta-analysis conducted by Huang et al. (2023), which aimed to identify the effects of different modalities and intensities of exercise on changes in body composition in overweight and obese children and adolescents, reported that combined exercise of two intensities was the most effective intervention in promoting reductions in fat mass and percentage of body fat. From this result, it can be presumed that the intensities of 60 – 80% of reserve heart rate used in the intervention by Jung et al. (2018) were sufficient to promote greater energy expenditure and, consequently, reduction in body fat percentage (Wilhelm, Pinto, 2019). The study by Saraiva et al. (2021) also reported a decrease in body fat percentage in the intervention group; however, it was reported that they were unable to maintain the desired intensity during the classes, in addition to the baseline body fat percentage being different between groups.

Another variable that showed a similar response to body fat percentage was fat mass in the studies by Saraiva et al. (2021) and Jung et al. (2018), where a significant reduction in this parameter was observed. However, in the studies by Nogueira et al. (2014) and Tsang et al. (2009), with longer interventions (9 and 6 months, respectively), no changes were observed, perhaps due to not controlling the intensity in their interventions or due to the low number of participants in these studies. Regarding the ideal type of exercise to reduce fat mass, combined exercise has been previously classified as the most suitable to achieve this goal (Grossman et al., 2017). This could be a possible explanation for the results observed in the meta-analysis of the present study, since combat sports combine aerobic and strength exercises in applying techniques (Bonitch Góngora et al., 2013), maintaining intensity between moderate and intense, so that the objectives regarding the modulation of these parameters in children and adolescents can be achieved.

Regarding lean mass, the meta-analysis did not detect differences in interventions with combat sports, similar to previous interventions using recreational and low-intensity aerobic activities, which also failed to promote an increase in lean mass in overweight and obese children (Vasconcellos et al., 2014; Cvetković et al., 2018). However, the study by Brasil et al. (2020), subjecting children and adolescents to Judo intervention with controlled intensity of 65 to 75% of maximum heart rate, showed positive results in increasing muscle mass in the overweight group post-intervention, emphasizing once again the importance of monitoring intensity and selecting the type of exercise to influence this variable.

Finally, total body mass was analyzed in all studies selected in the review, but the meta-analysis did not reveal benefits of combat sports for this variable. It is important to highlight that total body mass is a multifactorial variable and does not take into account components of body composition, which may result in the non-identification of changes in this variable. For

Journal of Sport and Health Research 2025, 18(1):1-18

example, an increase in lean body mass and a reduction in body adiposity may result in maintenance of total body mass. Although total body mass is of great importance in combat sports, given the division of weight categories by total body mass, it seems more important to assess the composition of lean mass and fat mass, rather than just evaluating body mass. Total body mass seems to be negatively associated with physical fitness tests in children (Riso et al., 2019), with body composition assessment being more recommended.

The results found in this systematic review with meta-analysis show that the effect of practicing combat sports on body composition in young adolescents is still controversial, as some studies found statistically significant differences post-intervention between groups, while other studies did not find such differences. Souza et al. (2020) found similar results in their systematic review on the effect of combat sports on body composition parameters in individuals of various age groups with overweight and obesity. Subsequently, Souza et al. (2021) published a randomized clinical trial with a 12-week karate intervention in adolescents, where they also did not find favorable results for the interventions compared to the control group, in any variable related to body composition.

Among the main limitations of this study is the low number of studies that met the eligibility criteria, which makes it difficult to reach a consensus on the findings. It is noted that some studies did not demonstrate intensity control, possibly one of the factors that influenced the results obtained, in addition to some methodological errors that increase the risk of bias, such as sample size calculation below the initially stipulated, lack of sample randomization, heterogeneity at baseline, and differences in genders were not taken into consideration. Furthermore, only articles in English were considered for this study, which is another limitation of the study. The overall quality of evidence, as assessed by the GRADE framework, was very low for most outcomes due to serious methodological flaws, imprecision, and inconsistency among the included studies, further limiting the reliability of the findings. For future studies, it is suggested that interventions have larger samples, control of class intensity, homogeneity between groups from the beginning of the intervention, and standardization of the tools used in body composition assessment.

Regarding the risk of bias, it was shown that most studies have a high risk, with only one study classified as "some risk," which highlights the need for more rigorous research to identify the effectiveness of the interventions presented and improve conclusions regarding the effects of practicing combat sports on the body composition of children and adolescents. The results of this study reinforce the importance of sports interventions in improving body composition, which could contribute to the development of more structured and effective programs. We believe that public policies could benefit from promoting sports as a strategy for health promotion. For future research, we suggest greater methodological rigor, larger sample sizes, and control of variables such as age and gender, aiming to generate more robust evidence to guide practices and decision-making.

CONCLUSION

In conclusion, based on the studies found and analyzed, combat sports practiced for at least 12 weeks, have shown to be effective in reducing the body mass index of children and adolescents. However, it was not possible to conclude their effectiveness in reducing lean body mass, fat body mass, total body mass, and body fat percentage.

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