

Effects of sports intervention on aggression in children and adolescents: A systematic review and meta-analysis (#82676)

1

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Effects of sports intervention on aggression in children and adolescents: A systematic review and meta-analysis

Yahui Yang¹, Hao Zhu², Kequn Chu¹, Yue Zheng³, Fengshu Zhu^{Corresp. 1}

¹ Yangzhou University, Yangzhou, Jiangsu, China

² Shanghai University of Sport, Shanghai, Shanghai, China

³ Jiangsu Vocational and Technical College of Economics and Trade, Nanjing, Jiangsu, China

Corresponding Author: Fengshu Zhu

Email address: fszhu@yzu.edu.cn

Objective To explore the impact of sports on aggression in children and adolescents and analyze whether different conditions in the intervention, such as type of sports, intervention duration, have different influence on the effect of interventions. **Method The study protocol was registered in PROSPERO (CRD42022361024).** We performed a systematic search of Pubmed, Web of science, Cochrane library, Embase and Scopus databases from database inception to 12 October 2022 for all studies written in English. Studies were included if they met the following PICO criteria. All analyses were carried out using the Review Manager 5.3 Software. We summarized aggression, hostility and anger scores using SMDs. Summary estimates with 95% confidence intervals were pooled using DerSimonian-Laird random effects model or fixed effects model according to between-study heterogeneity. **Results** 15 studies were deemed eligible for inclusion in this review. The overall mean effect size indicated that sport interventions **was** associated with lower aggression (SMD=-0.37, 95%CI:-0.69 to -0.06, P=0.020; $I^2=88\%$). Subgroup analyses showed that non-contact sports were associated with lower aggression (SMD=-0.65, 95%CI:-1.17 to -0.13, P=0.020; $I^2=92\%$) but high-contact sports were not (SMD=-0.15, 95%CI:-0.55 to 0.25, P=0.470; $I^2=79\%$). In addition, when intervention duration<6 months, sport interventions was associated with lower aggression (SMD=-0.99, 95%CI:-1.73 to -0.26, P=0.008; $I^2=90\%$) and when intervention duration \geq 6 months, sport interventions was not associated with lower aggression (SMD=-0.08, 95%CI:-0.44 to -0.28, P=0.660; $I^2=87\%$). **Conclusion** This review confirmed that sports intervention can reduce the aggression of children and adolescents. We suggested that schools can organize young people to participate in low-level, non-contact sports to reduce the occurrence of bullying, violence and other aggression-related adverse events.

Effects of Sports Intervention on Aggression in Children and Adolescents: A Systematic Review
and Meta-analysis

List of All Authors:

Yahui Yang¹, female, doctoral student of Sports Psychology, 1457560817@qq.com

Hao Zhu², male, doctoral student of Sports Psychology, 604404186@qq.com

Kequn Chu¹, male, doctoral student of Sports Psychology, 751404733@qq.com

Yue Zheng³, female, master of Sports Psychology, 544133216@qq.com

Fengshu Zhu¹, male, professor of Sports Psychology, 15252571909, fszhu@yzu.edu.cn

Affiliations of authors:

¹College of Physical Education, Yangzhou University, Yangzhou, China

²School of Psychology, Shanghai University of Sport, Shanghai, China

³School of Physical Education, Jiangsu Vocational and Technical College of Economics and Trade, Nanjing, China

Corresponding Author:

Fengshu Zhu

No.196 Huayang West Road, Yangzhou, Jiangsu, 225000, China

Email address: fszhu@yzu.edu.cn

Effects of Sports Intervention on Aggression in Children and Adolescents: A Systematic

Review and Meta-analysis

Abstract

Objective To explore the impact of sports on aggression in children and adolescents and analyze whether different conditions in the intervention, such as type of sports, intervention duration, have different influence on the effect of interventions.

Method The study protocol was registered in PROSPERO (CRD42022361024). We performed a systematic search of Pubmed, Web of science, Cochrane library, Embase and Scopus databases from database inception to 12 October 2022 for all studies written in English. Studies were included if they met the following PICO criteria. All analyses were carried out using the Review Manager 5.3 Software. We summarized aggression, hostility and anger scores using SMDs. Summary estimates with 95% confidence intervals were pooled using DerSimonian-Laird random effects model or fixed effects model according to between-study heterogeneity.

Results 15 studies were deemed eligible for inclusion in this review. The overall mean effect size indicated that sport interventions was associated with lower aggression (SMD=-0.37, 95%CI:-0.69 to -0.06, P=0.020; I²=88%). Subgroup analyses showed that non-contact sports were associated with lower aggression (SMD=-0.65, 95%CI:-1.17 to -0.13, P=0.020; I²=92%) but high-contact sports were not (SMD=-0.15, 95%CI:-0.55 to 0.25, P=0.470; I²=79%). In addition, when intervention duration<6 months, sport interventions was associated with lower aggression (SMD=-0.99, 95%CI:-1.73 to -0.26, P=0.008; I²=90%) and when intervention duration≥6

months, sport interventions **was** not associated with lower aggression (SMD=-0.08, 95%CI:-0.44 to -0.28, P=0.660; I²=87%).

Conclusion This review confirmed that sports intervention can reduce the aggression of children and adolescents. We suggested that schools can organize young people to participate in low-level, non-contact sports to reduce the occurrence of bullying, violence and other aggression-related adverse events.

Keywords Sports; Aggression; Child; Adolescent; Meta-Analysis

1.Introduction

Aggressive behavior (AB) is defined as acts that directly target others with the intention of causing immediate harm to others, such as violence and bullying (Anderson & Bushman, 2002; Azimi, Vaziri, & Kashani, 2012). Study reported that about 51% adolescents showed a high level of aggression in secondary school, and the aggressive tendency indicated a significant growth trend throughout adolescence (Hamza, et al., 2019). Adolescents aggression exert a negative impact on perpetrators, victims and bystanders in varying degrees (Wolke & Lereya, 2015). Bullying in adolescence increased the risks of poor academic performance, poor school adjustment, substance abuse, and violent and criminal behavior in later life (Moore, et al., 2017; Schoeler, et al.,2018). Aggression would not only lead the implementers to develop internalized emotional problems and externalized problem behaviors, but also bring serious psychological adaptation problems to the victims (Troop-Gordon, 2017). As a result of bullying, victims suffered adverse mental health, physical, and psychosomatic problems such as depression,

suicide, stomach aches, and insomnia (Moore, et al., 2017; Schoeler, et al.,2018). There were also psychological and behavioral problems reported by bystanders, such as anxiety, interpersonal sensitivity, and fears of further victimization (Rivers, et al., 2009). Aggression had seriously affected the physical and mental health, academic progress, personality development and social adaptation of adolescents (Gini & Pozzoli, 2013; Gini, Pozzoli, & Lenzi, 2014).

At present, many studies have confirmed that sport is inversely associated with adolescent violence. The energy can be released by venting people's aggressive impulse in an appropriate way, so as to eliminate the aggressive tendency. Regular participation in sports could reduce the aggression of young people, because it provided frequent energy release opportunities (Karin, Daniel, & Roland, 2010). Sports intervention has a positive effect on aggressive behavior of children and adolescents (Kim, 2016). The higher the physical activity level of school-age children, the lower their aggressive behavior(Pino-Juste, Portela-Pino, & Soto-carballo, 2019). Fung and Lee (2018) found that Chinese martial arts can effectively reduce the reactive and proactive aggression of school-age children. Sports can help reduce adolescent aggression. For example, after-school volleyball program may reduce aggressive behavior of adolescents by adjusting fun, motivation and self-control (Trajković, 2020). Participating in organized school sports can strengthen teenagers' sense of belonging and dependence on school, and these characteristics will guide them to create and maintain a positive and orderly school environment, so as to stay away from violent and destructive acts (Smith, 2011).

However, not all studies have found a negative relationship between sports and adolescent violence. A meta-analysis reported that there was no overall significant association between

sports participation and juvenile delinquency, sports participation could not reduce the occurrence of juvenile delinquency (Spruit, et al., 2016). Mendez, Ruiz-Esteban and Ortega (2019) indicated that students who practiced physical activity at least four or more times per week, had higher values in the indicators of aggressiveness than students who practiced less frequently. Michael et al. reported that some rough physical contact in sports, or even fighting, actually leads to an increase in adolescent aggression (Mutz & Baur, 2009). Kreager (2007) found that high-contact sports such as football and wrestling led to increased violence, while non-contact sports such as baseball and tennis did not. Zurita-Ortega et al (2015) reported that the overt aggressiveness of teenagers who practiced sport regularly was higher than sedentary teenagers, because they began to compete with each other.

This systematic review aims to integrate the existing research on sports intervention and explore the impact of exercise on children and adolescents' aggression. According to existing research, analyze whether different conditions in the intervention, such as type of sports, intervention duration, have different influence on the effect of interventions.

2.Methods

The study protocol was registered in PROSPERO (CRD42022361024).

2.1 Search strategy

We performed a systematic search of Pubmed, Web of science, Cochrane library, Embase and Scopus databases from database inception to 12 October 2022 for all studies written in English. The search strategy was designed by Yahui Yang and Fengshu Zhu by an initial scoping review of the literature. Studies were identified by using all possible combinations of the

following groups of search terms: (a) “adolescent” OR “teens” OR “youth” OR “teenager” OR “juvenile” OR “young” OR “minor”; (b) “physical training” OR “sport” OR “exercise” OR “athletics”; (c) “intervention” OR “behaviour change” OR “prevention” OR “experiment” OR “program” OR “reduction” OR “evaluation” OR “strategy” OR “effect”; (d) “aggression” OR “bullying” OR “violence” OR “assaultive behavior” OR “atrocious” OR “physical assault” OR “fighting”. The specific search was amended as necessary for each database to account for different search functionalities. The reference lists of retrieved articles and grey literature were searched to detect studies potentially eligible for inclusion.

2.2 Inclusion and exclusion criteria

Studies were included if they met the following PICO criteria: (1) included typically developing children and/or adolescents (Population); (2) examined different sports including school physical education programs (Intervention); (3) included an active/ inactive comparator (Comparison) and (4) examined associations with aggression (Outcomes). Studies were excluded if they focused on populations with developmental disorders (eg, Down syndrome).

2.3 Study selection

Search results were imported into Endnote to remove duplicates. Yahui Yang and Hao Zhu screened the titles and abstracts of the retrieved articles independently to remove irrelevant articles. Then the same reviewers independently screened remaining articles in full to determine the final included studies. Disagreements were resolved by consensus or consultation with Fengshu Zhu.

2.4 Data extraction

One reviewer extracted specific characteristics from included studies, including country, study design, participants characteristics (age, gender), sample size, intervention programme characteristics (name, type, duration, frequency), comparison programme and outcome variables. Keren et al. reported mean and standard deviation (SD) of baseline and change-from-baseline, the reviewer calculated the final mean and standard deviation according to Cochrane Handbook version 5.1.0 (Julian & Sally, 2011). Another reviewer confirmed the content.

2.5 Outcomes

The primary outcome was aggression scores. The secondary outcomes were other externalizing behaviors of aggression, including hostility, anger, delinquent acts, attitude towards violence (ATV) and provocation/bullying scores. If outcomes were reported for more than one time point, we extracted results closest to post-intervention (Fung & Lee, 2018). If two or more measurement tools were used, we referred to a previously described hierarchy of outcome measures (Fung & Lee, 2018). If physical aggression and verbal aggression scores were reported concurrently, we extracted the physical aggression scores (Trajković, et al., 2020a; Trajković, et al., 2020b; Shachar, et al., 2016; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant, 2002).

2.6 Risk of bias assessment

Yahui Yang and Hao Zhu assessed risk of bias of randomised controlled trials (RCTs) using the Cochrane collaboration tool 2.0 (Sterne, et al., 2019) and assessed risk of bias of quasi-experimental studies using the JBI Critical Appraisal Checklists for Quasi-Experimental Studies (The Joanna Briggs Institute, 2016) independently. Discrepancies were resolved by consensus or deliberation with Fengshu Zhu.

2.7 Data analysis

All analyses were carried out using the Review Manager 5.3 Software. We summarised aggression, hostility and anger scores using SMDs. Summary estimates with 95% confidence intervals were pooled using DerSimonian-Laird random effects model or fixed effects model according to between-study heterogeneity (DerSimonian & Laird, 1986). The heterogeneity was estimated using I^2 , considering I^2 values of < 25%, 25–50, and > 50% as small, medium, and large amounts of heterogeneity respectively (Higgins & Thompson, 2002). Subgroup moderator analyses were conducted to determine whether results differed according to intervention duration and sport type. Sensitivity analyses were used to explore the impact of individual studies. A narrative synthesis of the results was carried out using descriptive statistics in order to summarize characteristics of the studies where data cannot be extracted (Ioannidis, Patsopoulos, & Rothstein, 2008).

3.Results

3.1 Study characteristics and risk of bias

Following the screening process, 15 studies (Fung & Lee, 2018; Trajković, et al., 2020a; Trajković, et al., 2020b; Shachar, et al., 2016; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant, 2002; Mehralian, et al., 2022; Rosa, et al., 2021; Harwood-Gross, et al., 2021; Blomqvist, 2020; Wade, et al., 2018; Setty, Subramanya, & Mahadevan, 2017; Hortiguela, Gutierrez-Garcia, & Hernando-Garijo, 2017; Park, et al., 2017; Pels & Kleinert, 2016) were deemed eligible for inclusion in this review. The detailed screening flow is shown in Figure 1. Included studies were published between 2002 and 2022. Six studies were RCTs and nine studies were quasi-

experimental studies. Twelve studies reported aggression outcomes, five studies reported hostility and anger outcomes, two studies reported delinquent acts outcomes and attitude towards violence, and one study reported provocation/ bullying outcome. Three studies were comparison between two sports events with no control group. Pels and Kleinert (2016) carried out an single experiment and interventions of other studies varied in duration from 4weeks to 1 year (see Table 1 for details).

Six RCTs and nine quasi-experimental studies were all identified as “moderate quality”. The assessment results are shown in Table 2 and Table 3.

3.2 Impact of interventions on aggression

The overall mean effect size of 9 included studies (Fung & Lee, 2018; Trajković, et al., 2020a; Trajković, et al., 2020b; Shachar, et al., 2016; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant, 2002; Mehralian, et al., 2022; Wade, et al., 2018; Park, et al., 2017) was $SMD=-0.37$, 95% Confidence Interval (CI) -0.69, -0.06, indicating that sport interventions reduced aggression compared to a control group ($P=0.020$). There was significant heterogeneity between effect sizes between studies ($I^2=88\%$, $P<0.001$) (Figure 2).

According to the types of sport, non-contact sports (Trajković, et al., 2020a; Shachar, et al., 2016; Mehralian, et al., 2022; Wade, et al., 2018; Park, et al., 2017) were associated with lower aggression ($SMD=-0.65$, 95%CI:-1.17 to -0.13, $P=0.020$; $I^2=92\%$). High-contact sports (Fung & Lee, 2018; Trajković, et al., 2020b; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant, 2002) were not associated with lower aggression ($SMD=-0.15$, 95%CI:-0.55 to 0.25, $P=0.470$; $I^2=79\%$) (Table 4).

According to the intervention duration, when intervention duration < 6 months (Fung & Lee, 2018; Carraro, Gobbi, & Moè, 2014; Mehralian, et al., 2022; Park, et al., 2017), sport interventions was associated with lower aggression (SMD = -0.99, 95%CI: -1.73 to -0.26, P = 0.008; $I^2 = 90\%$). When intervention duration ≥ 6 months (Trajković, et al., 2020a; Trajković, et al., 2020b; Shachar, et al., 2016; Reynes & Lorant, 2002; Wade, et al., 2018), sport interventions was not associated with lower aggression (SMD = -0.08, 95%CI: -0.44 to -0.28, P = 0.660; $I^2 = 87\%$) (Table 4).

When the impact of individual studies was examined by removing studies from the analysis one at a time, we observed that when Mehralian et al (2022), Park et al (2017), Shachar et al (2016) and Carraro et al (2014) been removed, the pooled results became insignificant ($P \geq 0.05$) (Table 5). However, these studies did not share any specific characteristics.

Harwood-Gross et al (2021) only provided the mean change-score comparison between martial arts training and controls on aggression so that it was not included in the meta-analysis. The aggression scores in both groups were increased, and the difference was not significant ($P = 0.85$).

Blomqvist (2020) compared effects of Mixed Martial Arts (MMA) intervention and Brazilian Jiu-Jitsu (BJJ) intervention on aggression. The results showed that there was no significant main effect of aggression as a result of training ($P = 0.100$). However, the interaction between aggression and sport was significant ($P < 0.001$). Whereas MMA practitioners slightly increased their levels of aggression, BJJ practitioners reduced theirs. Pels and Kleinert (2016)

reported a significant reduction of aggressive feelings was found for participants exercising individually in the rowing condition compared with the individual combat exercise condition.

3.3 Impact of interventions on hostility

The overall mean effect size of 5 included studies (Trajković, et al., 2020a; Trajković, et al., 2020b; Shachar, et al., 2016; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant, 2002) indicated that sport interventions was associated with lower hostility (SMD=-0.29, 95%CI:-0.41 to -0.17, $P<0.001$; $I^2=0\%$) (Figure 3).

When the impact of individual studies was examined by removing studies from the analysis one at a time, we observed that the pooled results estimate remained consistent.

3.4 Impact of interventions on anger

The overall mean effect size of 5 included studies (Trajković, et al., 2020a; Trajković, et al., 2020b; Shachar, et al., 2016; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant, 2002) indicated that sport interventions was not associated with lower anger (SMD=-0.26, 95%CI:-0.56 to 0.03, $P=0.08$; $I^2=78\%$) (Figure 4).

Sensitivity analysis showed that when Reynes and Lorant (2002) been removed, the heterogeneity became small ($I^2=0\%$) and the pooled result became significant ($P<0.001$)(Table 5).

3.5 Impact of interventions on delinquent acts

Blomqvist (2020) indicated that both MMA and BJJ intervention groups reduced criminal behaviour moderately ($P=0.030$). Fung and Lee (2018) found that Chinese martial arts group had

light decrease in delinquent behavior than did the physical fitness training group, but there was no significant fixed effects of training were found in delinquent behavior ($P=0.760$).

3.6 Impact of interventions on attitude towards violence

Setty et al (2017) and Hortiguera et al (2017) reported effects of sport intervention on adolescents' attitude towards violence. Setty et al (2017) showed a significant change in both yoga and control groups in self-reported ATV, pre- and post-intervention ($p<0.05$). But the mean change in the yoga group is 39.59%, compared to 7.51% in the control group, indicating significant improvement. Hortiguera et al (2017) reported the results of two dimensions of ATV - unjustified violence and violence linked to self protection. The unjustified violence and the violence linked to self protection fell from high to medium in the judo and capoeira teaching units, significant difference with large effect sizes were found between the pre-test and the post-test in unjustified violence ($P=0.021$) while there was no difference in the control group.

3.7 Impact of interventions on provocation/bullying

Rosa et al (2021) carried out judo and ball games among children and adolescents. A significant improvement in the domain of provocation/bullying was observed after the interventions, with judo increasing 18.1% and ball games increasing 4.1%. In other words, the participants felt safer and more confident about other people's negative attitudes.

4. Discussion

This review evaluated the effectiveness of existing sports interventions to reduce aggression in children and adolescents. The overall results showed that sports intervention could reduce the aggression and hostility of children and adolescents and could not reduce the anger, while the

evidence is indeterminate at the domain level for delinquent acts, attitude towards violence and provocation/bullying.

A strong relationship between sport and aggression has been reported in the literature. Pino-Juste, Portela-Pino and Soto-Carballo (2019) reported that the higher the index of physical activity is, the lower the level of aggressiveness is. A systematic review pointed out that physical education played an important role in the prevention of bullying (Jimenez-Barbero, et al., 2020). Another review found that positive youth development Interventions with a physical activity component among pre- and early adolescents aged 8-14 years may lower bullying behaviors (Majed, 2022). Gråstén and Yli-Piipari (2019) indicated that violence among children and bullying reduced during the Physical Activity as Civil Skill Program according to teachers' written feedback. These are consistent with our results. The European Commission's White Paper on Sport (2007) pointed out that the social code implied in the sports include fair competition and team spirit, which can cultivate teenagers' social behavior patterns and reduce their aggressive behavior. Konrad Lorenz believed sport was a ritualize venting of aggression, which teaches people to consciously and responsibly control their fighting behavior (1966). However, the results of sensitivity analysis indicated the lack of robustness of the meta-analysis. This may be because the small sample sizes of the studies included in the meta-analysis and different basic characteristics of the studies led to a large heterogeneity of the pooled results, which requires cautious interpretation.

Subgroup analyses showed that non-cocontact sports were associated with lower aggression while high-contact sports were not. Sofia and Cruz (2017) surveyed 141 athletes from different

types of sport and found the same result: athletes from sports with higher levels of physical contact tended to be more aggressive than those from sports with lower levels of contact. This may be because self-control lies in the central role in the regulation of aggression in sport (Sofia & Cruz, 2015; Sofia & Cruz, 2016). High-contact sports mean strong competition and impulsivity. People who participate in non-contact sports could better control their aggressive behavior. In addition, the comparison between rowing and combat exercise also confirmed this opinion (Pels & Kleinert, 2016), the non-contact rowing can reduce aggression more than the high-contact combat.

Moreover, when the intervention duration ≥ 6 months, sport interventions was not associated with lower aggression. There is no study focusing on the influence of the duration of sport intervention on the effect of intervention currently. Richard (2017) confirmed that higher levels of participation in sports increased violence involvement. Méndez et al (2019) also indicated that students with high exercise frequency were more aggressive than those with low exercise frequency. Due to the large difference of intervention frequency among the included studies, we did not conduct subgroup analysis. According to the result, it could conceivably be hypothesised that whether the low level of sport involvement releases the aggressive impulse, and with the accumulation of exercise, the aggressive impulse rises again. As we all know, high level of exercise can improve muscle strength, and muscular strength may be an important predictor of aggression in bullying (Benítez-Sillero, et al., 2021), this view also supported our hypothesis.

From the above mentioned, we have reason to believe that low level of non-contact sports involvement may be more conducive to the release of aggressive impulses, so then reducing

aggressiveness of children and adolescents. Nevertheless, what kind of sport intervention frequency and duration can play the largest role in it needs further research.

5.Limitation

One limitation of this review was that the intervention programme of included studies were highly diversified with small sizes and varying assessment methods, which resulted in the high heterogeneity. Another limitation was that some of the included studies could not be meta-analysed due to the lack of standard control groups or the inability to extract data, so only descriptive statistics were made. Besides, the included studies were limited to peer-reviewed journals in English identified by the search strategy, potentially omitting other relevant studies.

6.Conclusion

This review confirmed that sports intervention can reduce the aggression of children and adolescents. We suggested that schools can organize young people to participate in low-level, non-contact sports to reduce the occurrence of bullying, violence and other aggression-related adverse events.

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Declaration of Interest Statement

The corresponding author was funded by ****. The funder did not influence the design of the study, the acquisition of data, the analysis, drafting of the manuscript or the decision to publish. Other authors declare no conflict of interest.

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451 **Tables**

Table 1 Characteristics of included studies

Study, Design, Country	Participants, Sample size, Age, Gender	Intervention programme	Comparison group	Intervention duration, frequency	Outcomes
Mehralian et al(2022) Quasi- experimental Study Iran	7-10 year old girls Int.n=15 (8 people aged 7 to 8 years and 7 people aged 9 to 10 years) Con.n=15 (8 people aged 7 to 8 years and 7 people aged 9 to 10 years)	A child yoga-based mindfulness training package	No training	10 one-hour training sessions	a
Rosa et al(2021) Randomized Clinical Trial Brazil	Children and adolescents Judo n=29 (9.90±1.56 years, 48% girls) Ball games n=36 (9.96±1.51 years, 30% girls)	<ul style="list-style-type: none"> ● Judo intervention ● Ball games, including football, volleyball, basketball, and handball 	/	12 weeks twice a week, lasting 60 min per session	f
Harwood-Gross et al(2021) Quasi-experimental Study Israel	Boys from schools for at-risk youths, located in low socioeconomic areas Int.n=20 Con.n=19 15.6±0.81 years	Martial arts classes	The same number of standard PE classes	6 months two 50-min classes per week	a
Trajković et al(2020a) RCT Serbia	Adolescents Int.n=56 (15.5±0.7 years, 30% girls) Con.n=51 (15.7±0.6 years, 37% girls)	Small-sided volleyball sessions and regular physical-education classes	Regular physical-education classes	8 months two scheduled 45-min sessions per week separated by at least 1 day	abc
Trajković et al(2020b) RCT Serbia	High school students Int.n=54 (15.7±0.6 years, 26% girls) Con.n=51 (15.8±0.5 years, 31% girls)	Recreational soccer sessions and regular physical-education classes	Regular physical-education classes	8 months 64 sessions after school: 45-min sessions per week, separated by at least 1 day	abc
Blomqvist et al(2020) Longitudinal Study Sweden	Students from local martial arts academies MMA n=63 BJJ n=50 20.14±2.43 years 7% girls	<ul style="list-style-type: none"> ● Mixed Martial Arts (MMA) intervention ● Brazilian Jiu-Jitsu (BJJ) intervention 	/	5 months at least twice a week	ad
Wade et al(2018) RCT Australia	Boys in public, secondary schools located in low-income areas Int.n=152 Con.n=137 12.7±0.5 years	ATLAS: a school-based, multicomponent physical activity program	No training	8 months continuous	a

Fung et al(2018) RCT Hong Kong	Children who scored ≥ 1 on the total score of the Reactive-Proactive Aggression Questionnaire Int.n=72 (8.63 \pm 1.06 years, 21% girls) Con.n=67 (8.57 \pm 1.11 years, 32% girls)	Wu gong (skill-based martial techniques): involved the basic hand-forms and foot stances, che quan (dragging punch), defense skills, and duichai (2-person combat sets)	The physical fitness training	10 90-minute weekly sessions	ad
Setty et al(2017) RCT India	Children Int.n=76 Con.n=82 12 years (13), 13 years (39), 14 years (36), 15 years (69), 16 years (1) 48% girls	Integrated yoga module	Moderate PE	4 weeks 1 hour a day, 5 days a week	e
Hortiguera et al(2017) Quasi-experimental Study Spain	Students from fourth year of Secondary Education Judo n=105 Ball games n=116 15.43 \pm 1.62 years 51% girls	Judo and capoeira teaching units	Football and basketball teaching units	16/17 sessions	e
Park et al(2017) Quasi-experimental Study Korea	Children Int.n= ¹⁴ (12.03 \pm 0.83 years) Con.n=25 (12.29 \pm 0.65 years) 50% girls	Supervised progressive PEC program	No training	8 weeks continuous	a
Pels et al(2016) Randomized Clinical Trial Germany	Psychology or sport science students attending local universities Rowing n=30 Combat n=30 24.05 \pm 3.31 years 45% girls	<ul style="list-style-type: none"> ● Rowing on an ergometer at a predefined pace of 12 kilometers per hour for five minutes ● A specific combat exercise for the duration of three minutes 	/	10min/ 6min once	a
Shachar et al(2016) Quasi-experimental Study Israel	Students had observed aggressive behavior in Grades 3-6 Int.n=330 Con.n=319 24% girls	A total of 120 hours of extra afterschool sports activities: comprising two weekly hours of martial arts and three weekly hours of other group sports activities	No training	24 weeks 5h a week	abc
Carraro et al(2014) RCT Italy	8th grade students Int.n=103 Con.n=107 13.27 \pm 0.48 years	The play fighting intervention consisted in a progression of games and exercises, implicating touch, physical contact and	Standard volleyball lessons	4 weeks 8 lessons, 2 times a week	abc

	42% girls	opposition				
Reynes et al(2002) Quasi-experimental Study France	Primary school boys n=55 Int.n=28 Con.n=27 8 years	Judo practice	No training	1 year 2 sessions per week	abc	

Note: a: Aggression;b: Hostility;c: Anger;d:Delinquent Acts;e: Attitude Towards Violence;f: Provocation/Bullying

Table 2 Risk of bias from RCTs

Study	1	2	3	4	5	6	7	8	9
Mehralian et al(2022)	Y	U	Y	Y	N	Y	Y	Y	Y
Rosa et al(2021)	Y	Y	Y	N	N	Y	Y	Y	Y
Harwood-Gross et al(2021)	Y	Y	N	Y	N	Y	Y	Y	Y
Blomqvist et al(2020)	Y	Y	U	N	Y	Y	Y	Y	Y
Hortiguella et al(2017)	Y	Y	N	Y	N	U	Y	Y	Y
Park et al(2017)	Y	Y	Y	Y	N	Y	Y	Y	Y
Pels et al(2016)	Y	U	Y	N	N	N/A	Y	Y	Y
Shachar et al(2016)	Y	Y	U	Y	Y	Y	Y	Y	Y
Reynes et al(2002)	Y	Y	Y	Y	N	Y	Y	Y	Y

Note: 1.Is it clear in the study what is the 'cause' and what is the 'effect'? 2.Were the participants included in any comparisons similar? 3.Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest? 4.Was there a control group? 5.Were there multiple measurements of the outcome both pre and post the intervention/exposure? 6.Was follow-up complete, and if not, was follow-up adequately reported and strategies to deal with loss to follow-up employed? 7.Were the outcomes of participants included in any comparisons measured in the same way? 8.Were outcomes measured in a reliable way? 9.Was appropriate statistical analysis used?

Y=Yes, N=No, U=Unclear, N/A=Not applicable

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Table 3 Risk of bias from quasi-experimental studies

Study	Selection bias		Performance bias	Detection bias	Attrition bias	Reporting bias	Other bias
	1	2	3	4	5	6	7
Trajković et al(2020a)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
Trajković et al(2020b)	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear
Wade et al(2018)	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear
Fung et al(2018)	Low risk	Low risk	Low risk	Unclear	Low risk	Low risk	Unclear
Setty et al(2017)	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear
Carraro et al(2014)	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear

Note: 1.Random sequence generation; 2.Allocation concealment; 3.Blinding of participants and personnel; 4.Blinding of outcome assessment; 5.Incomplete outcome data; 6.Selective reporting; 7.Other bias.

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Table 4 Subgroup analysis of aggression

Study characteristics	Number of studies (sample size)	SMD	95%CI	<i>P</i>	<i>I</i> ²
Type of sport					
Non-contact sport	5 (1114)	-0.65	-1.17, -0.13	0.020	92%
High-contact sport	4 (509)	-0.15	-0.55, 0.25	0.470	79%
Intervention duration					
<6 months	4 (427)	-0.99	-1.73, -0.26	0.008	90%
≥6 months	5 (1205)	-0.08	-0.44, 0.28	0.660	87%

Table 5 Sensitivity analysis of aggression, hostility and anger

Removed study	MD(95%CI)	<i>P</i>	<i>I</i> ²
Aggression			
Mehralian et al(2022)	-0. ¹⁴ (-0.48, 0.03)	0.080	81%
Trajković et al(2020a)	-0.44 (-0.78, -0.11)	0.010	80%
Trajković et al(2020b)	-0.40 (-0.76, -0.05)	0.030	89%
Wade et al(2018)	-0.43 (-0.80, -0.07)	0.020	88%
Fung et al(2018)	-0.42 (-0.77, -0.06)	0.020	89%
Park et al(2017)	-0.34 (-0.68, 0.00)	0.050	89%
Shachar et al(2016)	-0.36 (-0.74, 0.02)	0.060	87%
Carraro et al(2014)	-0.36 (-0.72, 0.01)	0.060	89%
Reynes et al(2002)	-0.46 (-0.78, -0.15)	0.004	87%
Hostility			
Trajković et al(2020a)	-0.30 (-0.42, -0.17)	<0.001	9%
Trajković et al(2020b)	-0.30 (-0.42, -0.18)	<0.001	5%
Shachar et al(2016)	-0. ¹⁴ (-0.41, -0.05)	0.010	0%
Carraro et al(2014)	-0.27 (-0.40, -0.14)	<0.001	5%
Reynes et al(2002)	-0.31 (-0.43, -0.19)	<0.001	0%
Anger			

Nebojša et al(2020a)	-0.19 (-0.56, 0.17)	0.300	83%
Nebojša et al(2020b)	-0.20 (-0.57, 0.17)	0.290	83%
Shachar et al(2016)	-0.18 (-0.62, 0.26)	0.430	81%
Carraro et al(2014)	-0. ¹⁴ (-0.65, 0.19)	0.280	83%
Reynes et al(2002)	-0.43 (-0.55, -0.31)	<0.001	0%

Figures

Figure 1 Flow chart of the selection process

Figure 2 Forest plot of studies for aggression

Figure 3 Forest plot of studies for hostility

Figure 4 Forest plot of studies for anger

Table 1(on next page)

Characteristics of included studies□ Risk of bias from RCTs and quasi-experimental studies; Subgroup analysis of aggression; Sensitivity analysis of aggression, hostility and anger

Table 1 Characteristics of included studies

Study, Design, Country	Participants, Sample size, Age, Gender	Intervention programme	Comparison group	Intervention duration, frequency
Mehralian et al(2022) Quasi- experimental Study Iran	7-10 year old girls Int.n=15 (8 people aged 7 to 8 years and 7 people aged 9 to 10 years) Con.n=15 (8 people aged 7 to 8 years and 7 people aged 9 to 10 years)	A child yoga-based mindfulness training package	No training	10 one-hour training sessions
Rosa et al(2021) Randomized Clinical Trial Brazil	Children and adolescents Judo n=29 (9.90±1.56 years, 48% girls) Ball games n=36 (9.96±1.51 years, 30% girls)	<ul style="list-style-type: none"> ● Judo intervention ● Ball games, including football, volleyball, basketball, and handball 	/	12 weeks twice a week, lasting 60 min per session
Harwood-Gross et al(2021) Quasi-experimental Study Israel	Boys from schools for at-risk youths, located in low socioeconomic areas Int.n=20 Con.n=19 15.6±0.81 years	Martial arts classes	The same number of standard PE classes	6 months two 50-min classes per week
Trajković et al(2020a) RCT Serbia	Adolescents Int.n=56 (15.5±0.7 years, 30% girls) Con.n=51 (15.7±0.6 years, 37% girls)	Small-sided volleyball sessions and regular physical-education classes	Regular physical-education classes	8 months two scheduled 45-min sessions per week separated by at least 1 day
Trajković et al(2020b) RCT Serbia	High school students Int.n=54 (15.7±0.6 years, 26% girls) Con.n=51 (15.8±0.5 years, 31% girls)	Recreational soccer sessions and regular physical-education classes	Regular physical-education classes	8 months 64 sessions after school: 45-min sessions per week, separated by at least 1 day
Blomqvist et al(2020) Longitudinal Study Sweden	Students from local martial arts academies MMA n=63 BJJ n=50 20.23±2.43 years 7% girls	<ul style="list-style-type: none"> ● Mixed Martial Arts (MMA) intervention ● Brazilian Jiu-Jitsu (BJJ) intervention 	/	5 months at least twice a week
Wade et al(2018) RCT Australia	Boys in public, secondary schools located in low-income areas Int.n=152 Con.n=137 12.7±0.5 years	ATLAS: a school-based, multicomponent physical activity program	No training	8 months continuous

Fung et al(2018) RCT Hong Kong	Children who scored $z \geq 1$ on the total score of the Reactive-Proactive Aggression Questionnaire Int.n=72 (8.63 \pm 1.06 years, 21% girls) Con.n=67 (8.57 \pm 1.11 years, 32% girls)	Wu gong (skill-based martial techniques): involved the basic hand-forms and foot stances, che quan (dragging punch), defense skills, and duichai (2-person combat sets)	The physical fitness training	10 90-minute weekly sessions
Setty et al(2017) RCT India	Children Int.n=76 Con.n=82 12 years (13), 13 years (39), 14 years (36), 15 years (69), 16 years (1) 48% girls	Integrated yoga module	Moderate PE	4 weeks 1 hour a day, 5 days a week
Hortiguera et al(2017) Quasi-experimental Study Spain	Students from fourth year of Secondary Education Judo n=105 Ball games n=116 15.43 \pm 1.62 years 51% girls	Judo and capoeira teaching units	Football and basketball teaching units	16/17 sessions
Park et al(2017) Quasi-experimental Study Korea	Children Int.n=23 (12.03 \pm 0.83 years) Con.n=25 (12.29 \pm 0.65 years) 50% girls	Supervised progressive PEC program	No training	8 weeks continuous
Pels et al(2016) Randomized Clinical Trial Germany	Psychology or sport science students attending local universities Rowing n=30 Combat n=30 24.05 \pm 3.31 years 45% girls	<ul style="list-style-type: none"> ● Rowing on an ergometer at a predefined pace of 12 kilometers per hour for five minutes ● A specific combat exercise for the duration of three minutes 	/	10min/ 6min once
Shachar et al(2016) Quasi-experimental Study Israel	Students had observed aggressive behavior in Grades 3-6 Int.n=330 Con.n=319 24% girls	A total of 120 hours of extra afterschool sports activities: comprising two weekly hours of martial arts and three weekly hours of other group sports activities	No training	24 weeks 5h a week
Carraro et al(2014) RCT Italy	8th grade students Int.n=103 Con.n=107 13.27 \pm 0.48 years 42% girls	The play fighting intervention consisted in a progression of games and exercises, implicating touch, physical contact and opposition	Standard volleyball lessons	4 weeks 8 lessons, 2 times a week

Reynes et al(2002) Quasi-experimental Study France	Primary school boys n=55 Int.n=28 Con.n=27 8 years	Judo practice	No training	1 year 2 sessions per week
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Note: ①Aggression;②Hostility;③Anger;④Delinquent Acts;⑤Attitude Towards Violence;⑥Provocation/Bullying

Table 2 Risk of bias from RCTs

Study	1	2	3	4	5	6	7	8	9
Mehralian et al(2022)	Y	U	Y	Y	N	Y	Y	Y	Y
Rosa et al(2021)	Y	Y	Y	N	N	Y	Y	Y	Y
Harwood-Gross et al(2021)	Y	Y	N	Y	N	Y	Y	Y	Y
Blomqvist et al(2020)	Y	Y	U	N	Y	Y	Y	Y	Y
Hortiguera et al(2017)	Y	Y	N	Y	N	U	Y	Y	Y
Park et al(2017)	Y	Y	Y	Y	N	Y	Y	Y	Y
Pels et al(2016)	Y	U	Y	N	N	N/A	Y	Y	Y
Shachar et al(2016)	Y	Y	U	Y	Y	Y	Y	Y	Y
Reynes et al(2002)	Y	Y	Y	Y	N	Y	Y	Y	Y

Note: 1.Is it clear in the study what is the 'cause' and what is the 'effect'? 2.Were the participants included in any comparisons similar? 3.Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest? 4.Was there a control group? 5.Were there multiple measurements of the outcome both pre and post the intervention/exposure? 6.Was follow-up complete, and if not, was follow-up adequately reported and strategies to deal with loss to follow-up employed? 7.Were the outcomes of participants included in any comparisons measured in the same way? 8.Were outcomes measured in a reliable way? 9.Was appropriate statistical analysis used?

Y=Yes, N=No, U=Unclear, N/A=Not applicable

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Table 3 Risk of bias from quasi-experimental studies

Study	Selection bias		Performance bias	Detection bias	Attrition bias	Reporting bias	Other bias
	1	2	3	4	5	6	7
Trajković et al(2020a)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
Trajković et al(2020b)	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear
Wade et al(2018)	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear
Fung et al(2018)	Low risk	Low risk	Low risk	Unclear	Low risk	Low risk	Unclear
Setty et al(2017)	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear
Carraro et al(2014)	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear

Note: 1.Random sequence generation; 2.Allocation concealment; 3.Blinding of participants and personnel; 4.Blinding of outcome assessment; 5.Incomplete outcome data; 6.Selective reporting; 7.Other bias.

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Table 4 Subgroup analysis of aggression

Study characteristics	Number of studies (sample size)	SMD	95%CI	<i>P</i>	<i>I</i> ²
Type of sport					
Non-contact sport	5 (1123)	-0.65	-1.17, -0.13	0.020	92%
High-contact sport	4 (509)	-0.15	-0.55, 0.25	0.470	79%
Intervention duration					
<6 months	4 (427)	-0.99	-1.73, -0.26	0.008	90%
≥6 months	5 (1205)	-0.08	-0.44, 0.28	0.660	87%

Table 5 Sensitivity analysis of aggression, hostility and anger

Removed study	MD(95%CI)	<i>P</i>	<i>I</i> ²
Aggression			
Mehralian et al(2022)	-0.23 (-0.48, 0.03)	0.080	81%
Trajković et al(2020a)	-0.44 (-0.78, -0.11)	0.010	80%
Trajković et al(2020b)	-0.40 (-0.76, -0.05)	0.030	89%
Wade et al(2018)	-0.43 (-0.80, -0.07)	0.020	88%
Fung et al(2018)	-0.42 (-0.77, -0.06)	0.020	89%
Park et al(2017)	-0.34 (-0.68, 0.00)	0.050	89%
Shachar et al(2016)	-0.36 (-0.74, 0.02)	0.060	87%
Carraro et al(2014)	-0.36 (-0.72, 0.01)	0.060	89%
Reynes et al(2002)	-0.46 (-0.78, -0.15)	0.004	87%
Hostility			
Trajković et al(2020a)	-0.30 (-0.42, -0.17)	<0.001	9%
Trajković et al(2020b)	-0.30 (-0.42, -0.18)	<0.001	5%
Shachar et al(2016)	-0.23 (-0.41, -0.05)	0.010	0%

Carraro et al(2014)	-0.27 (-0.40, -0.14)	<0.001	5%
Reynes et al(2002)	-0.31 (-0.43, -0.19)	<0.001	0%
Anger			
Nebojša et al(2020a)	-0.19 (-0.56, 0.17)	0.300	83%
Nebojša et al(2020b)	-0.20 (-0.57, 0.17)	0.290	83%
Shachar et al(2016)	-0.18 (-0.62, 0.26)	0.430	81%
Carraro et al(2014)	-0.23 (-0.65, 0.19)	0.280	83%
Reynes et al(2002)	-0.43 (-0.55, -0.31)	<0.001	0%

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Figure 1

Flow chart of the selection process

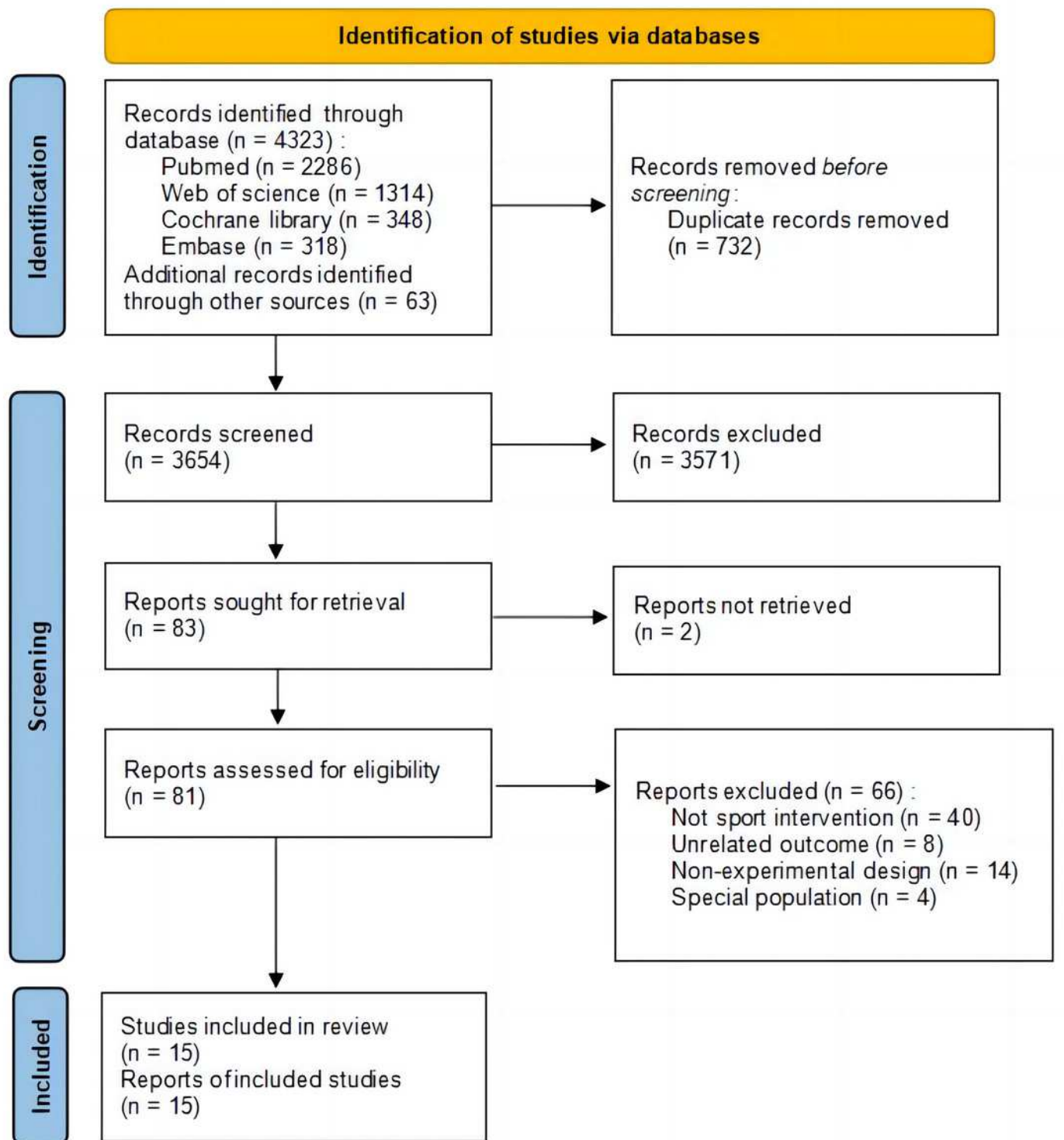


Figure 2

Forest plot of studies for aggression

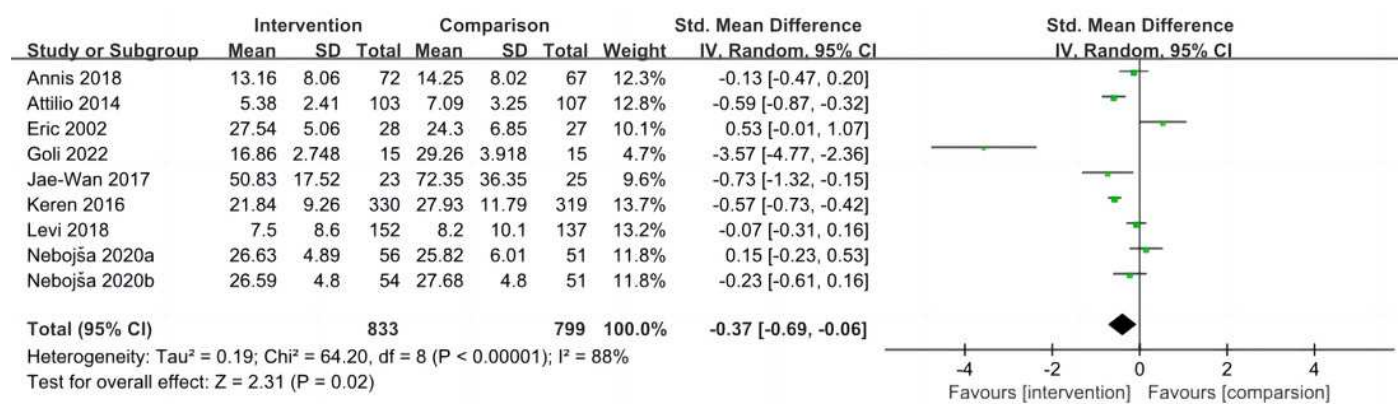


Figure 3

Forest plot of studies for hostility

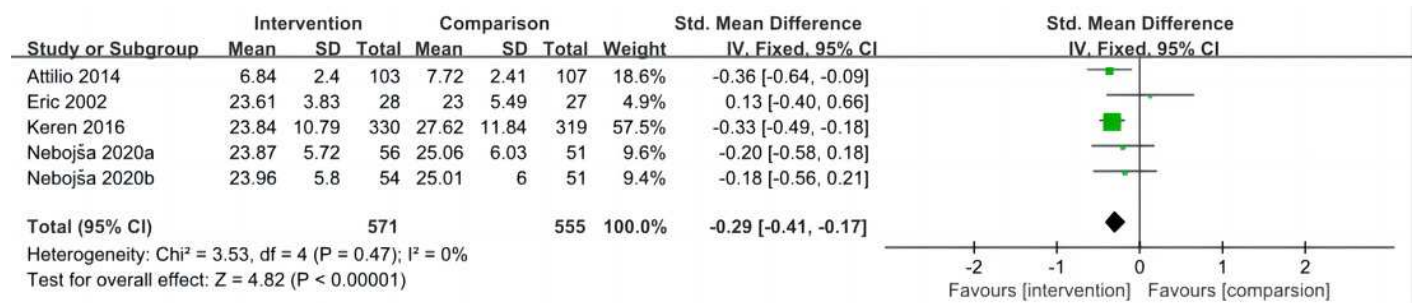


Figure 4

Forest plot of studies for anger

