

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

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*I commend the authors for their extensive data set, compiled over many years of detailed fieldwork. In addition, the manuscript is clearly written in professional, unambiguous language. If there is a weakness, it is in the statistical analysis (as I have noted above) which should be improved upon before Acceptance.*

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

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**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.

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

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

19 **Review and Meta-analysis**

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22 whether different conditions in the intervention, such as type of sports, intervention duration,

23 have different influence on the effect of interventions.

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25 systematic search of Pubmed, Web of science, Cochrane library, Embase and Scopus databases

26 from database inception to 12 October 2022 for all studies written in English. Studies were

27 included if they met the following PICO criteria. All analyses were carried out using the Review

28 Manager 5.3 Software. We summarized aggression, hostility and anger scores using SMDs.

29 Summary estimates with 95% confidence intervals were pooled using DerSimonian-Laird

30 random effects model or fixed effects model according to between-study heterogeneity.

31 **Results** 15 studies were deemed eligible for inclusion in this review. The overall mean effect

32 size indicated that sport interventions was associated with lower aggression (SMD=-0.37, 95%CI:-

33 0.69 to -0.06, P=0.020; I<sup>2</sup>=88%). Subgroup analyses showed that non-contact sports were

34 associated with lower aggression (SMD=-0.65, 95%CI:-1.17 to -0.13, P=0.020; I<sup>2</sup>=92%) but

35 high-contact sports were not (SMD=-0.15, 95%CI:-0.55 to 0.25, P=0.470; I<sup>2</sup>=79%). In addition,

36 when intervention duration<6 months, sport interventions **was** associated with lower aggression

37 (SMD=-0.99, 95%CI:-1.73 to -0.26, P=0.008; I<sup>2</sup>=90%) and when intervention duration≥6

38 months, sport interventions **was** not associated with lower aggression (SMD=-0.08, 95%CI:-0.44  
39 to -0.28, P=0.660; I<sup>2</sup>=87%).

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

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

45

## 46 **1. Introduction**

47 Aggressive behavior (AB) is defined as acts that directly target others with the intention of  
48 causing immediate harm to others, such as violence and bullying (Anderson & Bushman, 2002;  
49 Azimi, Vaziri, & Kashani, 2012). Study reported that about 51% adolescents showed a high level  
50 of aggression in secondary school, and the aggressive tendency indicated a significant growth  
51 trend throughout adolescence (Hamza, et al., 2019). Adolescents aggression exert a negative  
52 impact on perpetrators, victims and bystanders in varying degrees (Wolke & Lereya, 2015).

53 Bullying in adolescence increased the risks of poor academic performance, poor school  
54 adjustment, substance abuse, and violent and criminal behavior in later life (Moore, et al., 2017;  
55 Schoeler, et al., 2018). Aggression would not only lead the implementers to develop internalized  
56 emotional problems and externalized problem behaviors, but also bring serious psychological  
57 adaptation problems to the victims (Troop-Gordon, 2017). As a result of bullying, victims  
58 suffered adverse mental health, physical, and psychosomatic problems such as depression,

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

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

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

80 sports participation and juvenile delinquency, sports participation could not reduce the  
81 occurrence of juvenile delinquency (Spruit, et al., 2016). Mendez, Ruiz-Esteban and Ortega  
82 (2019) indicated that students who practiced physical activity at least four or more times per  
83 week, had higher values in the indicators of aggressiveness than students who practiced less  
84 frequently. Michael et al. reported that some rough physical contact in sports, or even fighting,  
85 actually leads to an increase in adolescent aggression (Mutz & Baur, 2009). Kreager (2007)  
86 found that high-contact sports such as football and wrestling led to increased violence, while  
87 non-contact sports such as baseball and tennis did not. Zurita-Ortega et al (2015) reported that  
88 the overt aggressiveness of teenagers who practiced sport regularly was higher than sedentary  
89 teenagers, because they began to compete with each other.

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

## 94 **2. Methods**

95 The study protocol was registered in PROSPERO (CRD42022361024).

### 96 *2.1 Search strategy*

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

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

109 *2.2 Inclusion and exclusion criteria*

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

115 *2.3 Study selection*

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

121 *2.4 Data extraction*

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

128 *2.5 Outcomes*

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

137 *2.6 Risk of bias assessment*

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

143 2.7 *Data analysis*

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

155 **3. Results**

156 *3.1 Study characteristics and risk of bias*

157 Following the screening process, 15 studies (Fung & Lee, 2018; Trajković, et al., 2020a;  
158 Trajković, et al., 2020b; Shachar, et al., 2016; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant,  
159 2002; Mehralian, et al., 2022; Rosa, et al., 2021; Harwood-Gross, et al., 2021; Blomqvist, 2020;  
160 Wade, et al., 2018; Setty, Subramanya, & Mahadevan, 2017; Hortiguela, Gutierrez-Garcia, &  
161 Hernando-Garijo, 2017; Park, et al., 2017; Pels & Kleinert, 2016) were deemed eligible for  
162 inclusion in this review. The detailed screening flow is shown in Figure 1. Included studies were  
163 published between 2002 and 2022. Six studies were RCTs and nine studies were quasi-

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

170 Six RCTs and nine quasi-experimental studies were all identified as “moderate quality”.

171 The assessment results are shown in Table 2 and Table 3.

### 172 *3.2 Impact of interventions on aggression*

173 The overall mean effect size of 9 included studies (Fung & Lee, 2018; Trajković, et al.,  
174 2020a; Trajković, et al., 2020b; Shachar, et al., 2016; Carraro, Gobbi, & Moè, 2014; Reynes &  
175 Lorant, 2002; Mehralian, et al., 2022; Wade, et al., 2018; Park, et al., 2017) was  $SMD=-0.37$ ,  
176 95% Confidence Interval (CI) -0.69, -0.06, indicating that sport interventions reduced aggression  
177 compared to a control group ( $P=0.020$ ). There was significant heterogeneity between effect sizes  
178 between studies ( $I^2=88\%$ ,  $P<0.001$ ) (Figure 2).

179 According to the types of sport, non-contact sports (Trajković, et al., 2020a; Shachar, et al.,  
180 2016; Mehralian, et al., 2022; Wade, et al., 2018; Park, et al., 2017) were associated with lower  
181 aggression ( $SMD=-0.65$ , 95%CI:-1.17 to -0.13,  $P=0.020$ ;  $I^2=92\%$ ). High-contact sports (Fung &  
182 Lee, 2018; Trajković, et al., 2020b; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant, 2002) were  
183 not associated with lower aggression ( $SMD=-0.15$ , 95%CI:-0.55 to 0.25,  $P=0.470$ ;  $I^2=79\%$ )  
184 (Table 4).

185 According to the intervention duration, when intervention duration<6 months (Fung & Lee,  
186 2018; Carraro, Gobbi, & Moè, 2014; Mehralian, et al., 2022; Park, et al., 2017), sport  
187 interventions was associated with lower aggression (SMD=-0.99, 95%CI:-1.73 to -0.26, P=0.008;  
188 I<sup>2</sup>=90%). When intervention duration≥6 months (Trajković, et al., 2020a; Trajković, et al., 2020b;  
189 Shachar, et al., 2016; Reynes & Lorant, 2002; Wade, et al., 2018), sport interventions was not  
190 associated with lower aggression (SMD=-0.08, 95%CI:-0.44 to -0.28, P=0.660; I<sup>2</sup>=87%) (Table  
191 4).

192 When the impact of individual studies was examined by removing studies from the analysis  
193 one at a time, we observed that when Mehralian et al (2022), Park et al (2017), Shachar et al  
194 (2016) and Carraro et al (2014) been removed, the pooled results became insignificant (P≥0.05)  
195 (Table 5). However, these studies did not share any specific characteristics.

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

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

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

207 *3.3 Impact of interventions on hostility*

208 The overall mean effect size of 5 included studies (Trajković, et al., 2020a; Trajković, et al.,  
209 2020b; Shachar, et al., 2016; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant, 2002) indicated  
210 that sport interventions was associated with lower hostility (SMD=-0.29, 95%CI:-0.41 to -0.17,  
211 P<0.001; I<sup>2</sup>=0%) (Figure 3).

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

214 *3.4 Impact of interventions on anger*

215 The overall mean effect size of 5 included studies (Trajković, et al., 2020a; Trajković, et al.,  
216 2020b; Shachar, et al., 2016; Carraro, Gobbi, & Moè, 2014; Reynes & Lorant, 2002) indicated  
217 that sport interventions was not associated with lower anger (SMD=-0.26, 95%CI:-0.56 to 0.03,  
218 P=0.08; I<sup>2</sup>=78%) (Figure 4).

219 Sensitivity analysis showed that when Reynes and Lorant (2002) been removed, the  
220 heterogeneity became small (I<sup>2</sup>=0%) and the pooled result became significant (P<0.001)(Table  
221 5).

222 *3.5 Impact of interventions on delinquent acts*

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

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

227 *3.6 Impact of interventions on attitude towards violence*

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

237 *3.7 Impact of interventions on provocation/bullying*

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

242 **4.Discussion**

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

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

248 A strong relationship between sport and aggression has been reported in the literature. Pino-  
249 Juste, Portela-Pino and Soto-Carballo (2019) reported that the higher the index of physical  
250 activity is , the lower the level of aggressiveness is. A systematic review pointed out that  
251 physical education played an important role in the prevention of bullying (Jimenez-Barbero, et  
252 al., 2020). Another review found that positive youth development Interventions with a physical  
253 activity component among pre- and early adolescents aged 8-14 years may lower bullying  
254 behaviors (Majed, 2022). Gråstén and Yli-Piipari (2019) indicated that violence among children  
255 and bullying reduced during the Physical Activity as Civil Skill Program  
256 according to teachers' written feedback. These are consistent with our results. The European  
257 Commission's White Paper on Sport (2007) pointed out that the social code implied in the sports  
258 include fair competition and team spirit, which can cultivate teenagers' social behavior patterns  
259 and reduce their aggressive behavior. Konrad Lorenz believed sport was a ritualize venting of  
260 aggression, which teaches people to consciously and responsibly control their fighting behavior  
261 (1966). However, the results of sensitivity analysis indicated the lack of robustness of the meta-  
262 analysis. This may be because the small sample sizes of the studies included in the meta-analysis  
263 and different basic characteristics of the studies led to a large heterogeneity of the pooled results,  
264 which requires cautious interpretation.

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

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

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

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

288 aggressiveness of children and adolescents. Nevertheless, what kind of sport intervention

289 frequency and duration can play the largest role in it needs further research.

290 **5.Limitation**

291 One limitation of this review was that the intervention programme of included studies were

292 highly diversified with small sizes and varying assessment methods, which resulted in the high

293 heterogeneity. Another limitation was that some of the included studies could not be meta-

294 analysed due to the lack of standard control groups or the inability to extract data, so only

295 descriptive statistics were made. Besides, the included studies were limited to peer-reviewed

296 journals in English identified by the search strategy, potentially omitting other relevant studies.

297 **6.Conclusion**

298 This review confirmed that sports intervention can reduce the aggression of children and

299 adolescents. We suggested that schools can organize young people to participate in low-level,

300 non-contact sports to reduce the occurrence of bullying, violence and other aggression-related

301 adverse events.

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304 **Declaration of Interest Statement**

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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)	● 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	● 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 $z \geq 1$ on the total score of the Reactive-Proactive Aggression Questionnaire Int.n=72 (8.63±1.06 years, 21% girls) Con.n=67 (8.57±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
Hortiguela et al(2017) Quasi-experimental Study Spain	Students from fourth year of Secondary Education Judo n=105 Ball games n=116 15.43 ± 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 ± 0.83 years) Con.n=25 (12.29 ± 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±3.31 years 45% girls	● 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±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

Rey়েস 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

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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
Hortiguela 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					
Trajković et al(2020a)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
Trajković et al(2020b)	Unclear	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear
Wade et al(2018)	Unclear	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear
Fung et al(2018)	Low risk	Low risk	Low risk	Unclear	Unclear	Low risk	Low risk	Unclear
Setty et al(2017)	Unclear	Unclear	Unclear	Unclear	Unclear	Low risk	Low risk	Unclear
Carraro et al(2014)	Unclear	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	P	$I^2$
<b>Type of sport</b>					
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%
<b>Intervention duration</b>					
<6 months	4 (427)	-0.99	-1.73, -0.26	0.008	90%
$\geq 6$ months	5 (1205)	-0.08	-0.44, 0.28	0.660	87%

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Table 5 Sensitivity analysis of aggression, hostility and anger

Removed study	MD(95%CI)	P	$I^2$
<b>Aggression</b>			
Mehralian et al(2022)	-0. <sup>14</sup> (-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%
<b>Hostility</b>			
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. <sup>14</sup> (-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%
<b>Anger</b>			

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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. <sup>14</sup> (-0.65, 0.19)	0.280	83%
Reynes et al(2002)	-0.43 (-0.55, -0.31)	<0.001	0%

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468 **Figures**

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470 Figure 1 Flow chart of the selection process

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473 Figure 2 Forest plot of studies for aggression

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476 Figure 3 Forest plot of studies for hostility

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479 Figure 4 Forest plot of studies for anger

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**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)	● 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	● 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±1.06 years, 21% girls) Con.n=67 (8.57±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
Hortiguela 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"> <li>Rowing on an ergometer at a predefined pace of 12 kilometers per hour for five minutes</li> <li>A specific combat exercise for the duration of three minutes</li> </ul>	/	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 8th grade students	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	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
Hortiguela 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					
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	P	$I^2$
<b>Type of sport</b>					
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%
<b>Intervention duration</b>					
<6 months	4 (427)	-0.99	-1.73, -0.26	0.008	90%
$\geq 6$ months	5 (1205)	-0.08	-0.44, 0.28	0.660	87%

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Table 5 Sensitivity analysis of aggression, hostility and anger

Removed study	MD(95%CI)	P	$I^2$
<b>Aggression</b>			
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%
<b>Hostility</b>			
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%

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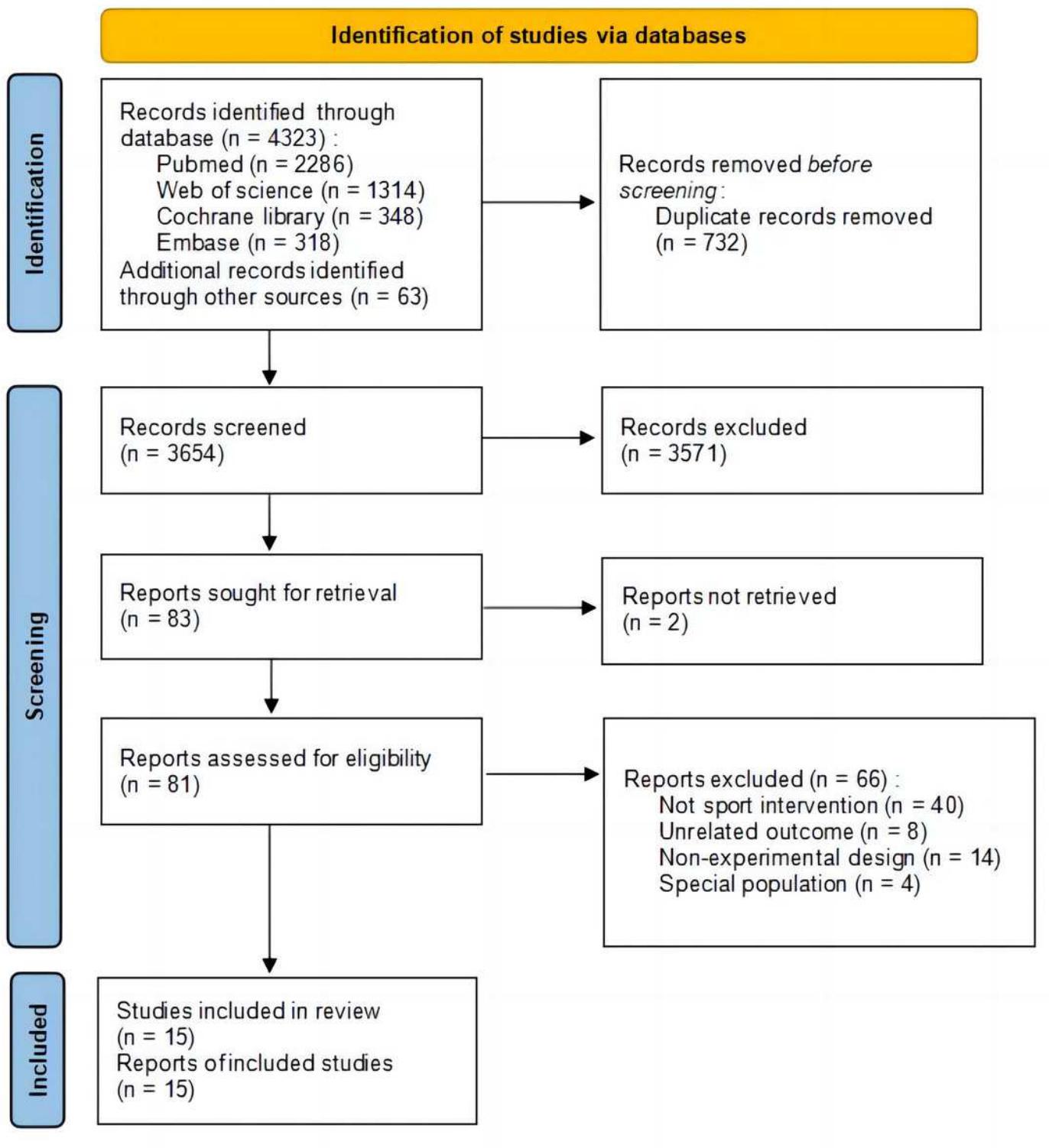
Carraro et al(2014)	-0.27 (-0.40, -0.14)	<0.001	5%
Reynes et al(2002)	-0.31 (-0.43, -0.19)	<0.001	0%
<b>Anger</b>			
Nebojša et al(2020a)	-0.19 (-0.56, 0.17)	0.300	83%
Nebojša et al(2020b)	-0.20 (-0.57, 0.17)	0.290	83%
Shachar et al(2016)	-0.18 (-0.62, 0.26)	0.430	81%
Carraro et al(2014)	-0.23 (-0.65,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

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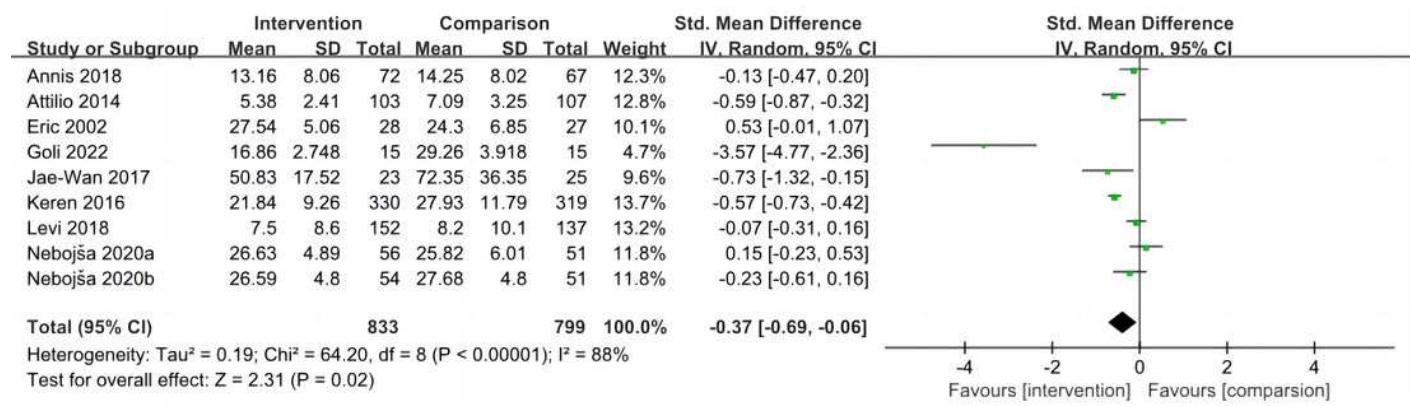
# Figure 1

Flow chart of the selection process



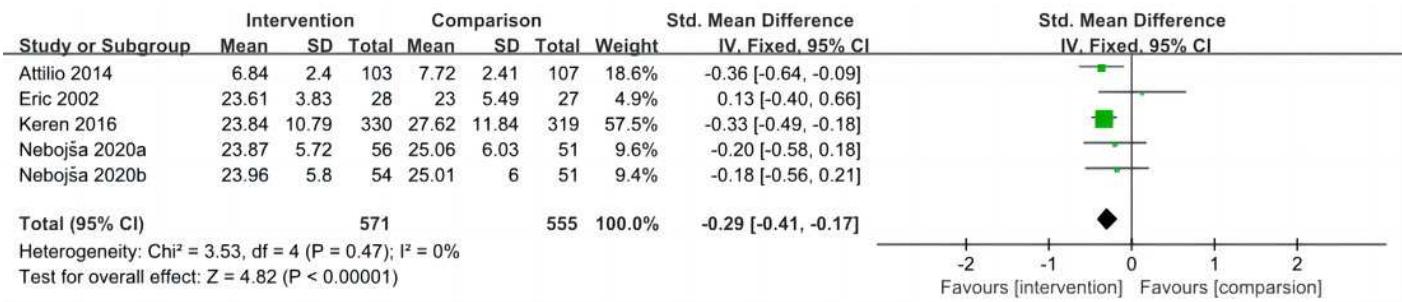
# Figure 2

## Forest plot of studies for aggression



# Figure 3

## Forest plot of studies for hostility



# Figure 4

## Forest plot of studies for anger

