

Review

A meta-analytic review of anger management activities that increase or decrease arousal: What fuels or douses rage?

Sophie L. Kjærøvik^a, Brad J. Bushman^{a,*}^a The Ohio State University, USA

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ABSTRACT

Anger is an unpleasant emotion that most people want to get rid of. Some anger management activities focus on decreasing arousal (e.g., deep breathing, mindfulness, meditation), whereas others focus on increasing arousal (e.g., hitting a bag, jogging, cycling). This meta-analytic review, based on 154 studies including 184 independent samples involving 10,189 participants, tested the effectiveness of both types of activities. The results indicated that arousal-decreasing activities decreased anger and aggression ($g = -0.63, [-0.82, -0.43]$), and the results were robust. Effects were stable over time for participants of different genders, races, ages, and cultures. Arousal-decreasing activities were effective in students and non-students, in criminal offenders and non-offenders, and in individuals with and without intellectual disabilities. Arousal-decreasing activities were effective regardless of how they were delivered (e.g., digital platforms, researchers, therapists), in both group and individual sessions, and in both field and laboratory settings. In contrast, arousal-increasing activities were ineffective overall ($g = -0.02, [-0.13, 0.09]$) and were heterogeneous and complex. These findings do not support the ideas that venting anger or going for a run are effective anger management activities. A more effective approach for managing anger is “turning down the heat” or calming down by engaging in activities that decrease arousal.

A growing proportion of the world's population feels angry (Gallup, 2022). Anger is a common reaction to provocation (Carver & Harmon-Jones, 2009; Frijda, 1986; Shaver, Schwartz, Kirson, & O'Connor, 1987). The interpretation of provocation can be influenced by the situation and the level of arousal experienced (Schachter & Singer, 1962). For example, a traffic jam may not automatically increase anger, but if a person has a job interview and the traffic jam is blocking them from getting to the interview on time, it can cause them to become angrier and perhaps even a more aggressive driver (Bjureberg & Gross, 2021). Acting on anger can lead to physical altercations, road rage incidents, injuries, and even deaths. This meta-analytic review examines the management of angry feelings using activities that decrease or increase arousal. First, we define anger.

1. What is Anger?

We use the following definition for anger: “Anger is an emotional response to a real or imagined threat or provocation” (Baumeister & Bushman, 2021, p. 201). Anger varies on a continuum from minimal anger to intense fury and rage (Deffenbacher, Oetting, Lynch, & Morris,

1996a). The physiologically arousal component of anger also varies on a continuum from little arousal to pronounced sympathetic arousal, increased muscle tension, and released adrenaline (Deffenbacher et al., 1996a).

2. Dimensions of emotions: valence and arousal

All emotions, including anger, can be characterized along two dimensions: (1) valence (i.e., positive vs. negative) and (2) arousal (i.e., low vs. high; Harmon-Jones, 2004). The valence of emotion is based on the emotion evoking event. Positive valence is pleasant, whereas negative valence is unpleasant. Anger is a negative emotion. However, anger differs from other negative emotions (e.g., fear, sadness, and disgust) because it motivates approach tendencies and action readiness rather than avoidance tendencies and withdrawal (Carver & Harmon-Jones, 2009). Anger is a natural emotional-physiological response primarily defined as negative valence and high in arousal. The situations that elicit anger are generally experienced as unpleasant, undesirable, and aversive (Carver & Harmon-Jones, 2009). Anger arouses and preserves high-level energy, quickly increases motoric mobility, and directs blood to the

* Corresponding author at: School of Communication, The Ohio State University, 3016 Derby Hall, 154 North Oval Mall, Columbus, OH, USA.

E-mail addresses: Sophie.Kjaervik@vcuhealth.org (S.L. Kjærøvik), bushman.20@osu.edu (B.J. Bushman).

muscles to prepare the body for action (Izard & Ackerman, 2000). Thus, anger makes people feel stronger and more prepared to attack, fight, or assault the cause of the anger (Frijda, 1986; Shaver et al., 1987).

3. Theoretical foundations

Anger has been explained using the same theories as other emotions. Theories of emotion have emphasized the role of arousal to a different extent. Some theories suggest that physiological arousal is the most essential component of emotion (e.g., James, 1884, 1890; Lange, 1885), whereas some theories suggest that cognition is the most essential component of emotion (e.g., Lazarus, 1982). Other theories argue that both components are essential (e.g., Schachter & Singer, 1962).

Over a century ago, scholars theorized that emotions arise from physiological changes due to some stimulus and that discrete emotional experiences can be identified with unique patterns of bodily changes (James, 1884; Lange, 1885). This theory was later called the James-Lange theory because William James and Carl Lange independently proposed similar theories (James & Lange, 1922). They argued that the conscious experience of emotion was built on the sense of a change in bodily state. Thus, automatic nervous system activity was considered essential to perceiving emotion (James, 1884; James & Lange, 1922; Lange, 1885).

Contrary to physiological theories of emotion, appraisal theories of emotion consider cognition as essential to emotions (Lazarus, 1982; Moors, Ellsworth, Scherer, & Frijda, 2013). Appraisal theories view emotions as adaptive responses that reflect appraisals or evaluations of situations. Appraisals are different for individuals, societies, and cultures, and can lead to different emotions and behavioral reactions depending on whether people have the same appraisals (Lazarus, 1982; Lazarus, 1991; Moors et al., 2013). Lazarus (1982) proposed that stimuli elicit thinking that can result in the experience of physiological and emotion responses at the same time. The most essential difference between positive and negative emotions, according to appraisal theories, is whether the individual interprets and experiences the eliciting event as pleasant or unpleasant (Lazarus, 1991). Thus, cognition is viewed as necessary for both emotion and arousal (Lazarus, 1982; Moors et al., 2013).

The theoretical foundation for this meta-analysis is the Schachter and Singer's (1962) theory, which has both physiological arousal and cognitive components. Arousal is caused by the sympathetic nervous system and dictates the presence and intensity of emotion, whereas the cognitive label dictates what specific emotion a person will feel at a given time. Schachter and Singer's (1962) two-factor theory of emotion assumes that in emotion-evoking situations people experience physiological arousal, followed by seeking environmental cues that can explain what caused the arousal, which they use to label their emotions.

4. Anger management

Because anger can have numerous negative consequences, it is widely seen as a problem and an emotion that should be heavily regulated. The negative valence and unpleasantness associated with anger also make people want to get rid of it (Carver & Harmon-Jones, 2009). However, most people report that they do not have efficient techniques for controlling their anger (Tice & Baumeister, 1993). Thus, there is a great need for identifying effective strategies for reducing and managing anger. This need has made anger management into a thriving industry (e.g., therapists, workshops, websites, videos, books). Moreover, instead of serving jail time, thousands of "angry people" are ordered by judges to take anger management courses for misdemeanor crimes (e.g., disturbance of peace, altercations, destruction of property, threatening behavior, aggressive neighbor disputes; Sanderfer & Johnson, 2015).

As noted previously, anger is associated with high physiological arousal and an unpleasant cognitive label. To manage anger, a person can focus on either of these.

4.1. Arousal

By reducing the state of arousal, through relaxing, controlling ones external and internal response, lowering heart rate, letting the feelings subside, and engaging in activities to lower arousal, a person can control or "turn down" their anger (Spielberger, 1988; Deffenbacher et al., 1996a). There are several possible ways to reduce arousal. Simply counting to a given number (e.g., 10 or 100) before responding might be enough to reduce anger because it provides time for the arousal to dissipate (Lohr, Olatunji, Baumeister, & Bushman, 2007). Moreover, research suggests that relaxation and stress-reduction breathing exercises such as diaphragm or deep breathing, muscle relaxation, progressive muscle relaxation, yoga, meditation, and biofeedback are useful in decreasing physiological arousal associated with anger and aggression (Feldman, 2016; Gaines & Barry, 2008; Hillman & Chapman, 2018). In contrast, some activities people use to manage their anger increase arousal (e.g., going for a run, hitting or kicking a bag). This meta-analytic review will examine all studies that have used activities designed to decrease or increase arousal levels.

4.2. Cognitive label

Schachter and Singer (1962) argue that the mental meaning assigned to the arousal state is the "cognitive label." By changing the cognitive label associated with the situation or bodily sensation, a person may be able to change their experience of emotion. Cognitive behavioral theory focuses on altering the cognitive distortions and irrational beliefs that lead a person to respond to an event with anger (Toohey, 2021). Several meta-analyses have already shown that cognitive behavior therapy is an effective anger management treatment (for a review see; Lee & DiGiuseppe, 2018). Therefore, this meta-analysis focuses on the effectiveness of altering arousal on anger, hostility, and aggressive behavior.

5. Present meta-analytic review of anger management

This is not the first anger management meta-analysis. To date, we located 16 meta-analyses (Beck & Fernandez, 1998; Candelaria, Fedewa, & Ahn, 2012; Del Vecchio & O'Leary, 2004; DiGiuseppe & Tafrate, 2003; Edmondson & Conger, 1996; Gansle, 2005; Hamelin, Travis, & Sturme, 2013; Henwood, Chou, & Browne, 2015; Ho, Carter, & Stephenson, 2010; Kusmierska, 2011; Nicoll, Beail, & Saxon, 2013; Ouyang & Liu, 2023; Saini, 2009; Sukhodolsky, Kassinove, & Gorman, 2004; Tafrate, 1995; Yang, Zhu, Chu, Zheng, & Zhu, 2023). However, prior meta-analyses have primarily focused on cognitive behavioral therapy treatments (Lee & DiGiuseppe, 2018), except for two meta-analyses that focused on sport activities among children and adolescents (Ouyang & Liu, 2023; Yang et al., 2023). Unfortunately, prior meta-analyses have largely neglected the importance of physiological arousal in the experience of anger, even though arousal is a central component of anger.

This meta-analytic review also improves on past meta-analyses in five other ways. First, we preregistered our meta-analysis. Second, our meta-analysis includes studies with participants of all ages, includes both published and unpublished studies, and examines several theoretical and exploratory moderator variables. Third, we conducted a comprehensive battery of sensitivity analyses to examine whether the results are robust to publication bias and/or outliers (for an example see Kjaervik & Bushman, 2021; see Supplemental Materials). Fourth, we account for the correlated nature of effect sizes. Fifth, we consider the use of random assignment and differential attrition in treatment and control groups as possible internal validity threats (see, Cook & Campbell, 1979).

6. Variables coded in present meta-analytic review

6.1. Outcomes

6.1.1. Anger

Most scholars distinguish between state and trait anger (e.g., Deffenbacher, Oetting, Thwaites, et al., 1996b; Spielberger, 1988). State anger refers to an emotional-physiological experience of anger that is temporary, occasional, and related to the immediate situation, whereas trait anger refers to a stable tendency to experience state anger more frequently and intensely across situations (Deffenbacher et al., 1996b). This meta-analysis examines both state and trait anger.

6.1.2. Hostility

Hostility refers to the cognitive aspect of anger separate from physiological arousal and overt behavior (Buss, 1961). Hostility is rooted in a set of negative beliefs about the general nature of humans (Vannoy, 2005). Although both anger and hostility involve negative affect and can arise in response to perceived threats or injustice, anger is primarily associated with an intense emotion characterized by physiological arousal and a strong desire to confront the source of perceived harm or wrongdoing. In contrast, hostility refers to a more enduring and pervasive disposition characterized by a general negative outlook towards others. Thus, hostility is often more reflective of beliefs and attitudes (see Barefoot, Dodge, Peterson, Dahlstrom, & Williams Jr, 1989; Spielberger, Krasner, & Solomon, 1988). Different activities may be required to address anger and hostility. Thus, by measuring hostility separately from anger, we can gain a more nuanced understanding of their distinct implications and assess the most effective activities. This meta-analysis will examine whether physiological arousal activities have different impact on the cognitive experience of hostility than on the emotional experience of anger.

6.1.3. Aggressive behavior

Anger is an internal emotion, whereas aggression is an external behavior (Lohr et al., 2007). Thus, aggression should be distinguished from anger, even though aggression can be a way of expressing anger. Aggression refers to “any form of behavior directed towards the goal of harming or injuring another living being who is motivated to avoid such treatment” (Baron & Richardson, 1994, p. 7). Aggression can be elicited by anger arousal, but aggression can also occur without anger arousal (Lohr et al., 2007). This meta-analysis also examines whether physiological arousal activities affect aggressive behavior.

6.2. Provocation

In experimental studies, provocation is often used to induce an angry state. Thus, we coded whether participants were provoked prior to receiving an anger management activity.

6.3. Arousal

Anger is linked to an increase in physiological arousal, vigor, and more energetic behavior (Novaco, 1976). Under high levels of arousal, anger can interfere with task performance and cognitive processes and cause more impulsive reactions (Novaco, 1976). When agitated, people tend to act without thinking and are more likely to have angry outbursts (Novaco, 1976). Performing activities that decrease cardiovascular activity (e.g., deep breathing, relaxation, mindfulness, meditation, slow flow yoga) should decrease anger (Tafrate, 1995). In contrast, performing activities that increase cardiovascular activity (e.g., hitting or kicking a punching bag, jogging, swimming, cycling) should increase anger (Bushman, 2002). This meta-analysis will examine how decreasing and increasing arousal affects anger. We also coded the specific task/activity participants were assigned to complete.

6.3.1. Mixed arousal and cognition

Studies sometimes use activities that include both arousal and cognitive components. For example, arousal-decreasing activities may use cognitive elements to guide participants to pay attention to breathing or relaxing muscles. In contrast, arousal-increasing activities may use cognitive elements to promote competitiveness and readiness for the physical challenge participants are asked to complete. Other arousal-increasing activities, such as traditional martial arts, have deep roots in ancient Eastern philosophies and spiritual traditions and incorporate cognitive elements such as discipline, patience, humility, and compassion (Cynarski & Lee-Barron, 2014). Therefore, we coded whether the activity included only an arousal component or both arousal and cognitive components.

6.4. Arousal-increasing activities

6.4.1. Aggressive vs. nonaggressive activity

If the activity increased arousal, we coded whether it was aggressive in nature (e.g., kickboxing, punching a bag, breaking objects in a rage room, shooting a paintball gun) or nonaggressive in nature (e.g., cycling, jumping a rope, jogging, running). Aggressive activities might increase physiological arousal and the bodily fight response more than nonaggressive activities.

6.4.2. Cardio vs. strength activity

We coded whether the physical activity focused on cardio or strength. Because cardio activities often cause a greater increase in heart rate than strength activities (Hurley et al., 1984), cardio activities might contribute to a greater increase in anger.

6.5. Source characteristics

6.5.1. Published in a peer-reviewed journal

Publication bias occurs when “the research that appears in the published literature is systematically unrepresentative of the population of complete studies” (Rothstein, Sutton, & Borenstein, 2005, p. 1). Thus, only including research reports from peer-review journals can result in an unrepresentative subset of studies. As one indication of publication bias, we coded whether the study was published in a peer reviewed journal. In addition, we conducted a comprehensive battery of sensitivity analyses to provide a more rigorous indication of publication bias (e.g., Kepes, Banks, McDaniel, & Whetzel, 2012; Kjærviik & Bushman, 2021).

6.5.2. Pre-registered

Preregistration is the practice of providing documentation of planned hypotheses, methods, and analyses of a scientific study prior to conducting the study (APA, 2021; Nosek, Ebersole, DeHaven, & Mellor, 2018). Preregistration ensures that the research team shares a clear understanding of the goals and processes of their research, separates the confirmatory aspects of the research from the exploratory aspects, and allows journal editors to accept the research paper regardless of the results (APA, 2021). Preregistered studies are therefore more likely to be published than non-preregistered studies (APA, 2021). We coded whether the study was preregistered.

6.5.3. Year

We coded the year of data collection to explore if effects are stable over time.

6.6. Participant characteristics¹

6.6.1. Gender

Previous research indicates that males have higher levels of anger than females (Kring, 2000). Thus, we coded the percentage of male participants in studies.

6.6.2. Race

As an exploratory variable, we also coded the percentage of White participants.

6.6.3. Age

Research indicate that anger decreases with age, with the highest levels at ages 30 to 50 and the lowest levels after age 80 (Schieman, 1999). Furthermore, the socioemotional selectivity theory suggests that older adults are more stable in their emotions and are less impacted by stressors than younger adults (Carstensen, 1992). However, no meta-analysis has examined age as a moderator. In this meta-analysis, we coded the mean age of participants.

6.6.4. College students

College students can differ from non-college students in several ways. Most relevant to this meta-analysis, late adolescence represents a time in life when people can be more overwhelmed by their own emotions and are less empathic towards others than later in adulthood (Sears, 1986). This meta-analysis explores whether the effectiveness of anger management activities differ for student and non-student samples.

6.6.5. Criminal offenders

One previous meta-analysis focused on adult criminal offenders and reported that anger management moderately reduced recidivism (Hennwood et al., 2015). In this meta-analysis we coded whether the sample included participants with a criminal history.

6.6.6. People with intellectual disabilities

Two prior meta-analyses focused on adults with intellectual disabilities and found large effects of anger management treatments (e.g., Hamelin et al., 2013; Nicoll et al., 2013). In this meta-analysis we coded whether participants had an intellectual disability.

6.6.7. Culture

There are different norms for expressing and experiencing emotions across cultures (Bebko, Cheon, Ochsner, & Chiao, 2019; Mesquita & Frijda, 1992). Compared to individualistic cultures, collectivistic cultures encourage the suppression of negative emotions (Bebko et al., 2019). As an exploratory moderator, we coded whether participants were from an individualistic or collectivistic culture.

6.7. Study characteristics

6.7.1. Total number of sessions

Prior meta-analyses have diverged in their findings regarding the relation between the number of treatment sessions and anger reduction (Kusmierska, 2011; Saini, 2009). As an exploratory moderator, we coded the number of treatment sessions.

6.7.2. Length of sessions

As an exploratory moderator, we coded the length of each treatment session in minutes.

6.7.3. Duration

Prior meta-analyses have diverged in their findings regarding the relation between the duration of activities and anger reduction (Kusmierska, 2011; Saini, 2009). As an exploratory moderator, we coded the number of weeks participants received the treatment.

6.7.4. Delivery personnel

A prior meta-analysis coded whether anger management activities were implemented by graduate students or licensed therapists, but did not report whether this influenced the magnitude of effects (Saini, 2009). This meta-analysis explores whether the type of personnel providing the treatment influences the magnitude of effects.

6.7.5. Individual vs. group session

Research suggests that there might be a difference between anger management activities administered individually versus those administered in groups (see Lee & DiGiuseppe, 2018). Thus, we coded whether activities were performed in an individual or group setting.

6.7.6. Differential attrition between anger management and control groups

To assess differential attrition as a threat to internal validity (Cook & Campbell, 1979), we coded the difference between the number of participants that dropped out of the anger management group and the number that dropped out of the control group.

6.8. Design characteristics

6.8.1. Random assignment

The use of random assignment allows researchers to draw causal inferences (Cook & Campbell, 1979). A previous meta-analysis found larger effects for studies that used random assignment than for studies that did not (DiGiuseppe & Tafrate, 2003). We also coded whether researchers used random assignment.

6.8.2. Type of setting

Laboratory settings tend to produce higher internal validity, whereas field settings tend to produce higher external validity (Cook & Campbell, 1979). There has been some debate as to whether online and offline experiments produce different results (e.g., Reips, 2000). In addition, many counseling services (e.g., telehelp, betterhelp) and anger management classes are offered online. Thus, we coded whether the study was conducted in a laboratory, field, or online setting.

6.8.3. Type of report

One meta-analysis found larger effect sizes in studies that used self-report measures than in studies that used observational measures (Saini, 2009). We coded whether anger was assessed via self-report, other report, observational measure, or clinical interview.

7. Method

This meta-analysis was preregistered <https://osf.io/u3vjn/>.

7.1. Literature search

As in a recent meta-analysis (Körner, Röseler, Schütz, & Bushman, 2022), seven computer databases were used to locate relevant studies published through 12 January 2024: (1) Medline, (2) PsycINFO, (3) Educational Resources Information Center (ERIC), (4) PubMed, (5) ProQuest (6) Theses Global, and (7) BASE (Bielefeld Academic Search Engine). The last three databases were searched for unpublished studies to address potential publication bias (Rothstein et al., 2005). The terms for the outcome variables were (anger* OR angry OR hostile* OR rage OR aggress* OR violent*). Using the word AND, these outcome terms were combined with terms related to activities designed to increase arousal (express OR vent* OR exercis* OR "physical activity" OR cycl* OR

¹ In addition to these participant characteristics, we wanted to code whether participants had a psychiatric disorder, but there were too few studies to code this variable.

bicycle* OR bike OR run* OR jog* OR arous* OR climb* OR hike OR walk* OR play* OR “paintball” OR guns OR “laser tag” OR hit* OR punch* OR kick* OR scream* OR yell* OR shout* OR writ* OR journal* OR troll* OR flam* OR “blow off steam”) or activities designed to decrease arousal (mindful* OR meditat* OR yoga OR delay OR count OR relax* OR breath* OR biofeedback). All terms were selected based on our review of the anger management literature. The asterisk allows terms to have all possible endings (e.g., the term meditat* will retrieve studies that used the terms meditate, meditated, meditation, and meditating). The search terms were limited to be in the Title and/or Abstract.

To obtain studies that we might have missed, we took four additional steps. First, we searched through the reference sections of previous meta-analyses (i.e., Beck & Fernandez, 1998; Candelaria et al., 2012; Del Vecchio & O’Leary, 2004; DiGiuseppe & Tafrate, 2003; Edmondson & Conger, 1996; Hamelin et al., 2013; Henwood et al., 2015; Ho et al., 2010; Kusmierska, 2011; Lee & DiGiuseppe, 2018; Nicoll et al., 2013;

Ouyang & Liu, 2023; Saini, 2009; Sukhodolsky et al., 2004; Tafrate, 1995; Yang et al., 2023). Second, we searched through the reference sections of all retrieved studies. Third, we contacted all researchers of all retrieved studies and requested from them any published and unpublished anger management studies. Fourth, we sent an announcement requesting unpublished and published studies to seven Listservs: (1) European Association of Social Psychology, (2) International Society for Research on Aggression, (3) Society of Australasian Social Psychologists, (4) Society of Experimental Social Psychology, (5) Society for Personality and Social Psychology (Division 8 of APA), (6) Society for the Psychological Study of Social Issues (Division 9 of APA), and (7) Society for the Study of Peace, Conflict and Violence: Peace Psychology Division (Division 48 of APA).

7.2. Inclusion criteria

We used three inclusion criteria. First, studies had to include a

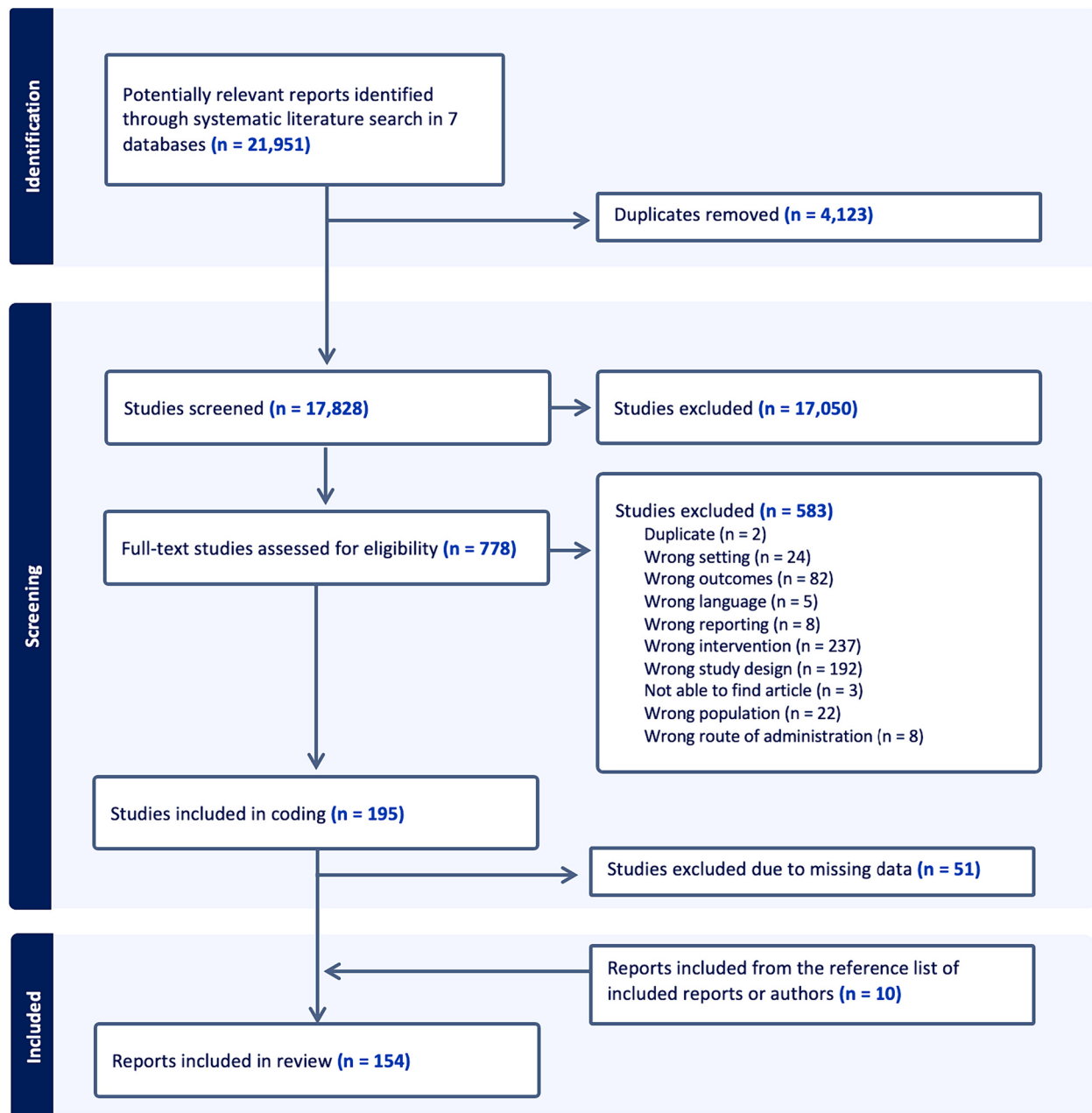


Fig. 1. PRISMA flowchart of literature search.

measure of anger, hostility, and/or aggression. Second, the study had to include an anger management activity designed to increase or decrease physiological arousal. Third, the study had to include a control condition if it was a between-subject design, or a pre- vs. post-comparison if it was a within-subject design.

7.3. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart

The literature search retrieved 21,951 research reports, but not all of them were pertinent to this meta-analysis. To determine whether research reports were relevant, one of us (SLK) and a research assistant read their titles and abstracts. It is recommended that at least two people decide independently what studies to include (Wilson, 2019). As shown in the PRISMA flowchart in Fig. 1, the final sample included 154 research reports (see Supplemental Materials), which included 184 independent studies involving 10,189 participants.

7.4. Outcomes

7.4.1. Anger

The most frequently used anger measure is the State-Trait Anger Expression Inventory (STAXI; Spielberger, 1988, 1996, or STAXI-2; Spielberger & Reheiser, 2004), which measures both state anger (e.g., “I feel angry”) and trait anger (e.g., “I am a hotheaded person”). Other measures of anger include the Multidimensional Anger Inventory (Siegel, 1986), which measures anger control and expression (e.g., “I get so angry, I feel like I might lose control”); the anger subscale of the Aggression Questionnaire (Buss & Perry, 1992), which measures feelings of anger (e.g., “I sometimes feel like a powder keg ready to explode”); and the Novaco Anger Inventory (Novaco, 1975), which measures the degree to which the participant feels angry or annoyed in different situations (e.g., “someone makes a mistake and blames it on you”).

7.4.2. Hostility

The most frequently used measure of hostility is the Cook-Medley Hostility Scale (Cook & Medley, 1954; e.g., “Most people will use somewhat unfair means to gain profit or an advantage rather than to lose it”). Another common measure is the hostility subscale of the Aggression Questionnaire (Buss & Perry, 1992; e.g., “At times I feel I have gotten a raw deal out of life”).

7.4.3. Aggressive behavior

The most frequently used self-report measure of aggressive behavior is the Aggression Questionnaire (AQ; Buss & Perry, 1992), which measures both physical aggression (e.g., “Given enough provocation, I may hit another person”) and verbal aggression (e.g., “I have threatened people I know”). A common laboratory measure of aggressive behavior is the competitive reaction time task, where participants are given the opportunity to deliver unpleasant noise blasts through headphones to a fictional opponent each time they react faster than their opponent (Warburton & Bushman, 2019).

7.5. Provocation

Because of its natural connection to anger, we coded whether participants were provoked before the outcome was measured. A common method researchers use to provoke participants is to give them bogus negative evaluations on an essay they wrote (“This is one of the worst essays I have read!”; e.g., Bushman, 2002).

7.6. Arousal

We coded whether the treatment group focused on decreasing arousal or cardiovascular activity (e.g., deep breathing, relaxation,

mindfulness, meditation, slow flow yoga, progressive muscle relaxation, diaphragmic breathing, counting, time-out) or increasing arousal or cardiovascular activity (e.g., physical exercise/activity, expressing anger such as by yelling, hitting, or kicking). For arousal-increasing activities, we coded whether it was aggressive (e.g., kickboxing, punching a bag, screaming into a pillow, paintball, rage room, laser tag, hit golf balls, shoot guns) or nonaggressive (e.g., hot yoga, Pilates, cycling, jumping a rope, jogging, climbing rocks or ropes). We also coded whether it was a cardio vs. strength activity.

7.6.1. Mixed arousal and cognition

We coded whether participants in the treatment group completed an anger management activity that only included arousal components or that included both arousal and cognitive components.

7.7. Exploratory moderator variables

7.7.1. Source characteristics

7.7.1.1. Publication status. We coded whether the report was published in a peer reviewed journal as one indication of publication bias, although we used more formal procedures to assess publication bias as well (see Sensitivity Analyses in Supplemental Materials).

7.7.1.2. Pre-registered. We coded whether the study was preregistered. If authors did not report whether the study was preregistered, we assumed it was not.

7.7.1.3. Year. We coded the year the data were collected. When the authors did not report the year of data collection, we coded the year the article was published.

7.7.2. Participant characteristics

7.7.2.1. Gender. We coded the percentage of the sample that was male.

7.7.2.2. Race. We coded the percentage of the sample that was White.

7.7.2.3. Age. We coded the mean age of participants. Some studies that used college students as participants did not report their mean age. In this case, we imputed the average age ($M = 21.69$) from studies that used college students.

7.7.2.4. College students. We coded whether participants were college students.

7.7.2.5. Criminal offenders. We coded whether participants had a prior history of violence (e.g., domestic violence).

7.7.2.6. People with intellectual disabilities. We coded whether participants were diagnosed with an intellectual disability.

7.7.2.7. Culture. We coded whether participants were from an individualistic or collectivistic culture using the categorization provided by Hofstede, Hofstede, and Minkov (2005); countries with an individualism score > 50 were coded as individualistic.

7.7.3. Study characteristics

7.7.3.1. Total number of sessions. We coded the total number of anger management sessions. For example, if participants were asked to meditate each day for one week, we coded it as 7.

7.7.3.2. Length of sessions. We coded the number of minutes

participants performed the activity. For example, if participants meditated for 20 min each session, we coded it as 20.

7.7.3.3. Duration. We coded the number of weeks participants engaged in the activity. For example, if participants were asked to meditate every day for four weeks, we coded it as 4.

7.7.3.4. Delivery personnel. We coded who provided the treatment to the participants (e.g., therapist, psychologist, psychiatrist, faculty member, graduate student, trained instructor, digital device).

7.7.3.5. Individual vs. group session. We coded whether the activity session(s) were provided in an individual or group format. If it was provided in a group format, we coded the average number of group members.

7.7.3.6. Differential attrition between treatment and control groups. For between-subject design we computed the number of participants who dropped out of the treatment group minus the number of participants who dropped out of the control group.

7.7.4. Design characteristics

7.7.4.1. Study design. We coded whether researchers used a between-subjects design or a within-subjects design.

7.7.4.2. Random assignment. We coded whether assignment to conditions was random.

7.7.4.3. Type of setting. We coded whether the study was conducted in a laboratory setting, in a naturalistic field setting (e.g., school), or online.

7.7.4.4. Type of report. We coded whether the outcome was assessed via self-report, other report (e.g., parent, teacher, peer, significant other), observational measure, or clinical interview.

7.8. Intercode reliability

All studies were coded by two independent raters (SLK and a trained research assistant), which is called “double coding” (Cooper, 2016). The trained research assistants were blind to the research hypotheses. To evaluate intercode reliability, we used the kappa coefficient for categorical characteristics (Vevea, Zelinsky, & Orwin, 2019). The mean reliability coefficient was 0.97. The mean percent agreement on the coded study characteristics was 97.5%. Disagreements were resolved through discussion.

7.9. Missing data

If effect size data were missing, the authors of the research report were contacted. If they did not initially respond, they were contacted up to two more times. If they did not respond after three contacts, or if they could not provide the data, the data were coded as missing. We sent emails to 94 authors; 15 (16.0%) provided the statistics requested, and 19 (20.2%) said the data were unavailable. We obtained adequate statistics for 445 effect sizes (154 research reports). To obtain missing moderator variable information (e.g., race, age, dropouts), we sent emails to 65 authors; 8 (12.3%) authors provided the missing information.

7.10. Data analysis strategy

In this meta-analysis, anger management treatment vs. control was coded as a categorical variable, and the three dependent variables were coded as continuous variables (i.e., anger, hostility, aggression). Thus,

we used Hedges’s g standardized mean difference as the effect-size index, which corrects for small sample bias (Borenstein, Hedges, Higgins, & Rothstein, 2011; Hedges, 1981). It provides the number of standard deviations (SD) between treatment and control group means.

For studies with missing group sample sizes, we divided the total sample size by the number of groups. We computed other values from descriptive statistics, other effect sizes (i.e., d , η^2 , OR , or r), or test statistics (i.e., F -tests, t -tests, χ^2 -tests).

Data were analyzed using R Studio Version 4.3.0 (R Core Team, 2021). We used random-effects models, which assume that effect size estimates differ from population means by both sampling error on the subject-level and variability on the study-level (Borenstein et al., 2011). Although random-effects models are more conservative than fixed-effects models, fewer statistical assumptions are required, and generalizations can be drawn to a wider set of studies (Borenstein et al., 2011).

The amount of heterogeneity (i.e., τ^2) for the overall outcomes was estimated using the restricted maximum-likelihood estimator (Viechtbauer, 2005), the Q -test for heterogeneity (Cochran, 1954), and the I^2 statistic (Higgins & Thompson, 2002). Cook’s distances were used to examine whether studies may be outliers and/or influential in the context of the model (Viechtbauer & Cheung, 2010). A Cook’s distance larger than the median plus six times the interquartile range of the Cook’s distances is considered influential.

In this meta-analysis, the assumption of independent effects (Hedges, Tipton, & Johnson, 2010) was sometimes violated (e.g., multiple studies included more than one outcome variable). Thus, robust variance estimates were calculated to adjust standard errors of dependent effect-size point estimates and confidence intervals (Hedges et al., 2010) with the metafor v. 4.2.0 (Viechtbauer, 2010) and robmeta v. 2.0 (Fisher, Tipton, & Zhipeng, 2017) package in R (R Core Team, 2021).

Most meta-analysts urge caution when interpreting results from distributions with fewer than 10 effect sizes to prevent problems related to low statistical power and second-order sampling error (e.g., Kepes et al., 2012; Sterne et al., 2011). For distributions with fewer than 10 effect size estimates, we only provided descriptive statistics.

We also conducted a comprehensive battery of sensitivity analyses to determine whether the obtained results were robust to publication bias and/or outliers (e.g., see Supplemental Materials).

7.11. Transparency and openness

This meta-analysis was preregistered at <https://osf.io/u3vjn/>. The PRISMA-P checklist was followed to prepare the checklist and the PRISMA reporting guidelines were followed to report results. The plan can be found at <https://osf.io/u3vjn/> and the dataset can be found at <https://osf.io/u3vjn/>. Supplemental materials can be found at <https://osf.io/u3vjn/> and <https://osf.io/u3vjn/> and a study overview is available at <https://osf.io/u3vjn/>.

8. Results

This meta-analysis included 154 research reports, which included 184 independent samples involving 10,189 participants. First, we report the overall results of studies that used activities to decrease and increase physiological arousal. Second, we report each outcome variable for each type of activity. Third, we report the moderator variable analyses for each type of activity.

8.1. Overall effect of arousal

We coded whether the activity decreased or increased physiological arousal. There was a significant difference in effect sizes between the two types of studies, $F(1, 182) = 27.65, p < .0001$, suggesting that the two types of studies should be examined separately. As can be seen in Fig. 2, studies that tested activities intended to decrease arousal found that participants were less angry and aggressive. In contrast, studies that

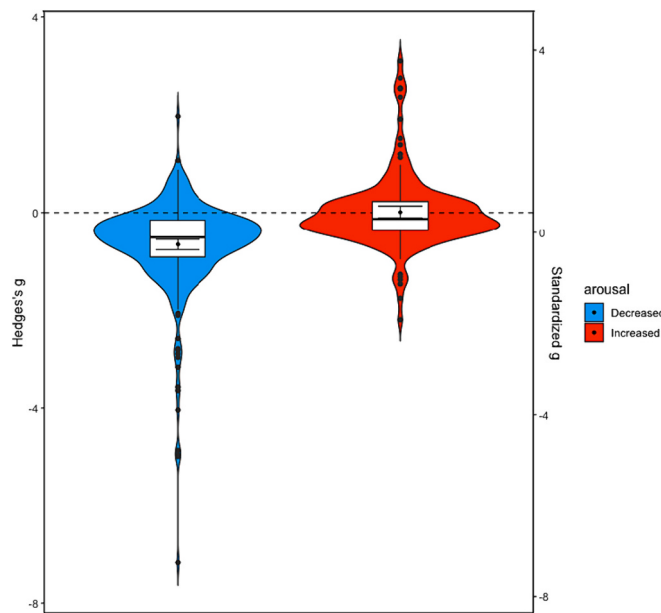


Fig. 2. Violin plots.

The plot width denotes the density of the distribution at a given Hedges's g . The center of each violin plot contains a boxplot. The mean effects are denoted as circles and the 95% CI bounds are denoted using capped vertical bars. Outliers are denoted by solid black circles. A horizontal dashed line is drawn at zero.

tested activities intended to increase arousal found nonsignificant effects on anger and aggression.

8.1.1. Arousal-decreasing activities

The average Hedges's g for the 114 studies intended to decrease arousal was -0.63 , with a 95% CI ranging from -0.82 to -0.43 , which excludes the value zero. The 25th, 50th, and 75th percentiles were -0.92 , -0.51 , and -0.16 , respectively. As can be seen in the violin plot on the left side of Fig. 2, the distribution is negatively skewed.

Effect sizes varied widely, ranging from -7.15 to 1.97 . According to the Q -test, the observed outcomes are heterogeneous, $Q(298) = 2134.53$, $p < .0001$, $\hat{\tau}^2 = 0.56$. The I^2 statistic indicates that 91.05% of the heterogeneity in the effect size estimate is due to between-study differences. According to the Cochrane Collaboration (Higgins et al., 2023), I^2 values $>75\%$ indicate considerable heterogeneity. Most effect sizes (86.29%) were negative.

8.1.2. Arousal-increasing activities

The average Hedges's g for the 73 studies intended to increase arousal was -0.02 , with a 95% CI ranging from -0.13 to 0.09 , which includes the value zero. The 25th, 50th, and 75th percentiles were -0.36 , -0.13 , and 0.23 , respectively. As can be seen in the violin plot on the right side of Fig. 2, the distribution is positively skewed.

Effect sizes varied widely, ranging from -2.20 to 3.10 . According to the Q -test, the observed outcomes are heterogeneous, $Q(145) = 762.45$, $p < .0001$, $\hat{\tau}^2 = 0.32$. The I^2 statistic reports that 88.62% of the heterogeneity in the effect size estimate is due to between-study differences, indicating considerable heterogeneity. About half of the effects (56.16%) were negative.

8.2. Theoretical moderators

The results for the outcome measures are in Table 1 and the results for the other theoretical moderator variables are in Table 2 (see Supplemental Materials).

8.2.1. Outcomes

Arousal-decreasing activities significantly reduced anger ($g = -0.55$, $[-0.74, -0.36]$, $k = 166$), hostility ($g = -0.53$, $[-0.83, -0.22]$, $k = 26$), and aggression ($g = -0.74$ $[-1.07, -0.41]$, $k = 102$). There was no significant difference in the magnitude of effects for the different outcomes, $F(2, 110) = 0.68$, $p = .51$.

Arousal-increasing activities did not significantly impact anger ($g = -0.07$, $[-0.20, 0.06]$, $k = 72$), hostility ($g = 0.17$, $[-0.19, 0.52]$, $k = 38$), or aggression ($g = -0.11$, $[-0.27, 0.05]$, $k = 36$). There was no significant difference in the magnitude of effects for the different outcomes, $F(2, 70) = 1.11$, $p = .34$.

8.2.1.1. State vs. trait anger. For arousal-decreasing activities, the effect was significant for both state measures ($g = -0.54$, $[-0.70, -0.39]$, $k = 97$) and trait measures ($g = -0.75$, $[-1.05, -0.46]$, $k = 27$), and the between-groups test was nonsignificant, $F(1, 61) = 1.75$, $p = .19$.

For arousal-increasing activities, the effect was nonsignificant for state measures ($g = -0.03$, $[-0.22, 0.17]$, $k = 47$). Only seven studies used trait measures ($g = -0.06$, $[-0.24, 0.11]$).

8.2.2. Provocation

For arousal-decreasing activities, the average effect size was nonsignificant for provoked participants ($g = -0.22$, $[-0.45, 0.0004]$, $k = 18$), and was significant for unprovoked participants ($g = -0.68$, $[-0.90, -0.46]$, $k = 265$). The two effect sizes significantly differed [$F(1, 104) = 8.22$, $p = .005$].

For arousal-increasing activities, the average effects did not differ for provoked participants ($g = -0.07$, $[-0.34, 0.20]$, $k = 23$) and unprovoked participants ($g = -0.009$, $[-0.14, 0.12]$, $k = 123$), [$F(1, 71) = 0.19$, $p = .66$], and both 95% CIs contained zero.

8.2.3. Arousal-decreasing activities

8.2.3.1. Type of activity. All arousal-decreasing activities significantly reduced anger: Meditation ($g = -1.55$, $[-2.22, -0.87]$, $k = 38$), mindfulness ($g = -0.53$, $[-0.70, -0.36]$, $k = 152$), relaxation ($g = -0.45$, $[-0.65, -0.26]$, $k = 75$), and yoga ($g = -0.41$, $[-0.63, -0.19]$, $k = 28$). The effect sizes significantly differed, $F(3, 106) = 3.47$, $p = .02$.

8.2.3.2. Mixed arousal and cognition. We coded whether the activity was focused on arousal (e.g., muscle relaxation, jogging, weight training) or both arousal and cognition (e.g., mindfulness-based cognitive therapy, cognitive-relaxation therapy, loving-kindness meditation). Most activities used a mixture of arousal and cognition. Activities with cognitive components ($g = -0.73$, $[-0.98, -0.48]$, $k = 221$) were more effective at reducing anger than activities without cognitive components ($g = -0.34$, $[-0.51, -0.17]$, $k = 78$), $F(1, 112) = 6.72$, $p = .01$. Both 95% CIs excluded zero.

8.2.4. Arousal-increasing activities

8.2.4.1. Aggressive activity. Effects were similar in size and nonsignificant for aggressive activities ($g = -0.03$, $[-0.12, 0.05]$, $k = 31$) and non-aggressive activities ($g = -0.05$, $[-0.21, 0.10]$, $k = 93$), $F(1, 63) = 0.06$, $p = .81$.

8.2.4.2. Cardio vs. strength activities. Effects were similar in size and nonsignificant for cardio activities ($g = -0.05$, $[-0.19, 0.09]$, $k = 113$) and strength activities ($g = -0.02$, $[-0.12, 0.08]$, $k = 17$), $F(1, 62) = 0.09$, $p = .76$.

8.2.4.3. Type of activity. Jogging ($g = 0.71$, $[0.07, 1.42]$, $k = 17$) and stair climbing ($g = 0.23$, $[0.16, 0.31]$, $k = 2$) significantly increased anger, whereas ball sports ($g = -0.36$, $[-0.67, -0.05]$, $k = 7$), physical education classes ($g = -0.30$, $[-0.49, -0.12]$, $k = 13$), and aerobic

exercise ($g = -0.29$, $[-0.53, -0.05]$, $k = 22$) significantly decreased anger. The effects were nonsignificant for the other arousal-increasing activities: Rowing ($g = 0.66$, $[-0.07, 1.39]$, $k = 2$), walking ($g = -0.07$, $[-0.45, 0.30]$, $k = 10$), martial arts ($g = -0.006$, $[-0.08, 0.07]$, $k = 26$), weight training ($g = -0.04$, $[-0.16, 0.08]$, $k = 15$), punching or kicking an object ($g = -0.13$, $[-0.30, 0.03]$, $k = 7$), swimming ($g = -0.32$, $[-0.83, 0.19]$, $k = 6$), table tennis ($g = -0.44$, $[-1.59, 0.71]$, $k = 1$), speed running ($g = -0.52$, $[-1.59, 0.71]$, $k = 1$), and a mixture of rowing and martial arts ($g = -0.63$, $[-1.31, 0.06]$, $k = 2$). However, most effects should be interpreted with caution due to the small number of effects (<10).

8.2.4.4. Mixed arousal and cognition. Arousal increasing activities with cognitive components ($g = 0.06$, $[-0.10, 0.22]$, $k = 37$) did not differ from those without cognitive components ($g = -0.05$, $[-0.19, 0.10]$, $k = 109$), $F(1, 71) = 0.93$, $p = .33$. Both 95% CIs included zero.

8.3. Exploratory moderators

8.3.1. Source characteristics

8.3.1.1. Publication status. In studies with arousal-decreasing activities, the average effect size was significant for published studies ($g = -0.62$, $[-0.77, -0.46]$, $k = 227$) and nonsignificant for unpublished studies ($g = -0.66$, $[-1.35, 0.03]$, $k = 72$), and the two effects did not differ [$F(1, 112) = 0.02$, $p = .90$].

For studies with arousal-increasing activities, the average effect was nonsignificant for both published studies ($g = -0.02$, $[-0.16, 0.12]$, $k = 109$) and unpublished studies ($g = -0.02$, $[-0.23, 0.19]$, $k = 37$), and the two effects did not differ [$F(1, 71) = 0.0002$, $p = .99$].

8.3.1.2. Pre-registered. Arousal-decreasing activities decreased anger and aggression in the 292 non-preregistered studies, $g = -0.62$, $[-0.82, -0.41]$. Only 7 pre-registered studies used an activity designed to decrease arousal ($g = -1.09$, $[-2.21, 0.03]$).

Arousal-increasing activities did not influence anger and aggression in the 142 non-preregistered studies ($g = -0.02$, $[-0.14, 0.10]$). Only 4 pre-registered studies used an arousal-increasing activity ($g = 0.10$, $[-0.50, 0.69]$).

8.3.1.3. Year. The year of data collection did not significantly influence the magnitude of effects in studies that used arousal-decreasing activities ($b = -0.01$, $[-0.03, 0.009]$, $k = 114$) or in studies that used arousal-increasing activities ($b = 0.004$, $[-0.007, 0.02]$, $k = 73$).

8.3.2. Participant characteristics

8.3.2.1. Gender. In studies with arousal-decreasing activities, the percentage of the sample that was male ($M = 56.35\%$, $SD = 34.30$; $k = 9$ studies did not report gender) was not associated with the magnitude of effects ($b = -0.004$, $[-0.01, 0.004]$, $k = 105$).

In studies with arousal-increasing activities, the percentage of the sample that was male ($M = 63.92\%$, $SD = 34.55$; $k = 4$ studies did not report gender) was not associated with the magnitude of effects ($b = -0.003$, $[-0.007, 0.000]$, $k = 69$).

8.3.2.2. Race. In studies with arousal-decreasing activities, the percentage of the sample that was White ($M = 46.99\%$, $SD = 37.67$; $k = 7$ studies did not report race) was not associated with the magnitude of effects ($b = 0.003$, $[-0.005, 0.01]$, $k = 66$).

In studies with arousal-increasing activities, the percentage of the sample that was White ($M = 52.39$, $SD = 23.95$; $k = 43$ studies did not report race) was positively associated with the magnitude of effects ($b = 0.01$, $[0.002, 0.02]$, $k = 30$).

8.3.2.3. Age. The average age of participants was not associated with the magnitude of effects in studies with arousal-decreasing activities ($b = 0.004$, $[-0.01, 0.02]$, $k = 103$; $M_{age} = 29.02$, $SD = 14.32$; $k = 11$ did not report age) or in studies with arousal-increasing activities ($b = 0.001$, $[-0.004, 0.006]$, $k = 71$; $M_{age} = 24.02$, $SD = 15.34$; $k = 2$ did not report age).

8.3.2.4. College students. In studies with arousal-decreasing activities, there was no difference in the average effect sizes between student samples ($g = -0.57$, $[-0.78, -0.36]$, $k = 62$) and non-student samples ($g = -0.64$, $[-0.88, -0.40]$, $k = 237$), $F(1, 112) = 0.20$, $p = .65$, and both 95% CIs excluded zero.

In studies with arousal-increasing activities, the average effect size was positive for student samples ($g = 0.33$, $[0.03, 0.63]$, $k = 45$) and was negative for non-student samples ($g = -0.18$, $[-0.28, -0.08]$, $k = 101$), and the two effects differed [$F(1, 71) = 10.44$, $p = .002$]. Both 95% CIs excluded zero.

8.3.2.5. Criminal offenders. In studies with arousal-decreasing activities, the average effect size was significant for both criminal offenders ($g = -0.65$, $[-1.11, -0.19]$, $k = 45$) and non-offenders ($g = -0.62$, $[-0.84, -0.40]$, $k = 254$), and the two effects did not significantly differ, $F(1, 112) = 0.01$, $p = .92$.

In studies with arousal-increasing activities, the average effect size was nonsignificant for both criminal offenders ($g = 0.005$, $[-0.15, 0.16]$, $k = 5$) and non-offenders ($g = -0.02$, $[-0.14, 0.10]$, $k = 141$).

8.3.2.6. People with intellectual disabilities. In studies with arousal-decreasing activities, the average effect size was significant for participants with ($g = -0.84$, $[-1.68, -0.001]$, $k = 11$) and without ($g = -0.62$, $[-0.82, -0.41]$, $k = 288$) intellectual disabilities, and the two groups did not significantly differ, $F(1, 112) = 0.26$, $p = .61$.

In studies with arousal-increasing activities, the average effect size was nonsignificant for participants without intellectual disabilities ($g = 0.001$, $[-0.11, 0.11]$, $k = 143$). Only 3 studies used participants with intellectual disabilities ($g = -1.63$, $[-1.81, -1.46]$).

8.3.2.7. Culture. For studies that used arousal-decreasing activities, effects were significant regardless of whether participants were from a collectivistic culture ($g = -0.95$, $[-1.48, -0.41]$, $k = 74$) or an individualistic culture ($g = -0.51$, $[-0.68, -0.35]$, $k = 225$), and the two effects did not differ, $F(1, 112) = 2.34$, $p = .13$.

In studies that used arousal-increasing activities, the effect size was negative if participants were from a collectivist culture ($g = -0.49$, $[-0.72, -0.25]$, $k = 19$) and was nonsignificant if participants were from an individualistic culture ($g = 0.05$, $[-0.08, 0.18]$, $k = 127$). The two effects differed, $F(1, 71) = 16.27$, $p = .0001$.

8.3.3. Study characteristics

8.3.3.1. Total number of sessions. In studies with arousal-decreasing activities, the total number of sessions ranged from 1 to 274 ($M = 13.54$, $SD = 28.62$; we omitted 3 studies that used 274 sessions, 1 study that used 112 sessions, and 19 studies that did not report the number of sessions). The number of sessions was not associated with the magnitude of effects ($b = -0.002$, $[-0.005, 0.002]$, $k = 278$).

In studies with arousal-increasing activities, the number of sessions ranged from 1 to 64 ($M = 16.81$, $SD = 19.09$; we omitted 31 studies that did not report the number of sessions). The number of sessions was negatively associated with anger and aggression ($b = -0.01$, $[-0.02, -0.0001]$, $k = 64$).

8.3.3.2. Length of each session. In studies with arousal-decreasing activities, the length of each session ranged from 5 to 960 min ($M = 98.49$, $SD = 124.95$; we omitted the 29 studies that did not report the length of

each session). The length of each session was not associated with the magnitude of effects ($b = 0.0003$, $[-0.0008, 0.001]$, $k = 270$).

In studies with arousal-increasing activities, the length of each session ranged from 2 to 90 min ($M = 38$, $SD = 22.19$; we omitted the 42 studies that did not report the length of each session). The length of each session was not associated with the magnitude of effects ($b = -0.008$, $[-0.02, 0.0008]$, $k = 104$).

8.3.3.3. Duration. The duration for studies with arousal-decreasing activities ranged from 0 to 72 weeks ($M = 8.21$, $SD = 7.91$; we omitted 19 studies that did not report duration). The number of weeks was not associated with the magnitude of effects ($b = -0.005$, $[-0.02, 0.008]$, $k = 280$).

The duration for studies with arousal-increasing activities ranged from 0 to 104 weeks ($M = 17.16$, $SD = 27.57$; we omitted 4 studies that did not report duration). Duration was not associated with the magnitude of effects ($b = -0.004$, $[-0.01, 0.003]$, $k = 142$).

8.3.3.4. Delivery personnel. Arousal-decreasing activities led by a psychologist/therapist ($g = -0.61$, $[-0.87, -0.35]$, $k = 42$), a researcher/graduate student/research staff ($g = -0.55$, $[-0.78, -0.32]$, $k = 109$), a trained instructor/trainer ($g = -0.78$, $[-1.22, -0.33]$, $k = 112$), or a digital device ($g = -0.40$, $[-0.50, -0.30]$, $k = 36$) were all significant. The between-group test was nonsignificant, $F(3, 110) = 1.83$, $p = .15$.

Arousal-increasing activities led by a trained instructor/trainer were significant ($g = -0.16$, $[-0.30, -0.02]$, $k = 61$), whereas arousal-increasing activities led by a researcher/graduate student/research staff were nonsignificant ($g = 0.08$, $[-0.11, 0.27]$, $k = 85$). The two effects differed, $F(1, 71) = 4.17$, $p = .04$.

8.3.3.5. Individual vs. group session. In studies with arousal-decreasing activities, both group sessions ($g = -0.65$, $[-0.89, -0.41]$, $k = 236$) and individual sessions ($g = -0.54$, $[-0.75, -0.32]$, $k = 63$) were significant, and the difference between them was nonsignificant, $F(1, 112) = 0.48$, $p = .49$.

In studies with arousal-increasing activities, group sessions ($g = -0.18$, $[-0.31, -0.05]$, $k = 75$) were significant, whereas individual sessions were not ($g = 0.15$, $[-0.07, 0.36]$, $k = 71$), and the difference between them was significant [$F(1, 71) = 7.02$, $p = .01$].

8.3.3.6. Differential attrition between treatment and control groups. Differential attrition did not influence the magnitude of effects in studies with arousal-decreasing activities ($b = -0.03$, $[-0.06, 0.001]$, $k = 77$) or in studies with arousal-increasing activities ($b = -0.02$, $[-0.07, 0.03]$, $k = 45$).

8.3.4. Design characteristics

8.3.4.1. Study design. In studies with arousal-decreasing activities, effect sizes were significant for both between-subjects designs ($g = -0.66$, $[-0.92, -0.39]$, $k = 180$) and within-subjects designs ($g = -0.58$, $[-0.75, -0.42]$, $k = 119$), and the two effects did not differ [$F(1, 112) = 0.44$, $p = .51$].

For studies with arousal-increasing activities, the effect was nonsignificant if a between-subject design was used ($g = 0.08$, $[-0.09, 0.26]$, $k = 92$) but was negative and significant if a within-subject design was used ($g = -0.18$, $[-0.31, -0.05]$, $k = 54$). The two effects differed, $F(1, 71) = 5.89$, $p = .02$.

8.3.4.2. Random assignment. For studies with arousal-decreasing activities, effects were significant if random assignment was used ($g = -0.69$, $[-0.96, -0.41]$, $k = 171$), but were nonsignificant if random assignment was not used ($g = -0.16$, $[-0.63, 0.32]$, $k = 11$). Although the effect size was noticeably larger if random assignment was used, the difference was nonsignificant [$F(1, 78) = 3.64$, $p = .06$] and the 95% CIs

overlapped.

For studies with arousal-increasing activities, the effect was nonsignificant regardless of whether random assignment was used ($g = 0.09$, $[-0.11, 0.29]$, $k = 75$) or was not used ($g = -0.03$, $[-0.43, 0.36]$, $k = 17$), and the two effects did not differ, $F(1, 55) = 0.10$, $p = .75$.

8.3.4.3. Type of setting. We coded whether the study was conducted in a field, laboratory, or online setting. In studies with arousal-decreasing activities, the average effect size was significant in both laboratory settings ($g = -0.51$, $[-0.66, -0.37]$, $k = 83$) and field settings ($g = -0.68$, $[-0.95, -0.40]$, $k = 210$), and the two effects did not differ, $F(1, 110) = 1.17$, $p = .28$. Only 6 studies were conducted online, $g = -0.36$, $[-0.98, 0.25]$.

In studies with arousal-increasing activities, the average effect size was negative in field settings ($g = -0.17$, $[-0.28, -0.07]$, $k = 96$) and was nonsignificant in laboratory settings ($g = 0.26$, $[-0.002, 0.51]$, $k = 50$), and the between-groups test was significant $F(1, 71) = 9.33$, $p = .003$.

8.3.4.4. Type of report. In studies with arousal-decreasing activities, the average effect size was negative for studies that used self-report measures ($g = -0.68$, $[-0.89, -0.46]$, $k = 271$) and nonsignificant for studies that used other-report measures ($g = -0.10$, $[-0.44, 0.24]$, $k = 23$). The two effects differed, $F(1, 108) = 8.25$, $p = .005$. The average effect size for the 4 studies that used behavioral observations was nonsignificant ($g = -0.31$, $[-0.62, 0.01]$).

In studies with arousal-increasing activities, the average effect size was nonsignificant for studies that used self-report measures, $g = -0.003$, $[-0.12, 0.12]$, $k = 138$. The 5 studies that used other-report measures found a significant effect ($g = -0.77$, $[-1.45, -0.08]$). The average effect size for the 2 studies that used behavioral observations was significant ($g = 0.23$, $[0.65, 0.30]$).

9. Discussion

9.1. Main findings

This meta-analysis found that decreasing physiological arousal can decrease anger and aggression, whereas increasing physiological arousal does not noticeably influence anger and aggression. In other words, these findings support the notion that turning down the flame can decrease the heat.

9.2. Outcomes

The main theoretical moderator in this meta-analysis was the type of outcome measure. For arousal-decreasing activities, there was no considerable difference between anger, aggression, and hostility measures. Decreasing arousal was effective across the board, even when participants were provoked. In recent years, the range of arousal-decreasing activities (e.g., mindfulness, meditation) have considerably increased (Sharma & Rush, 2014). This finding supports the view that decreasing arousal is an essential part of anger treatment neglected in cognitive behavioral therapy (Novaco, 2011).

Consistent with prior meta-analyses (i.e., Candelaria et al., 2012; Del Vecchio & O'Leary, 2004; Edmondson & Conger, 1996; Saini, 2009; Tafrate, 1995), this meta-analytic review found that relaxation-based activities effectively reduced anger. Progressive muscle relaxation is based on the idea that inducing relaxation in the body's muscles could lead to a corresponding relaxed state in the central and autonomic nervous systems, resulting in a more tranquil state of mind and a reduction in negative emotions such as anger (Jacobson, 1929). Progressive muscle relaxation reduces physiological arousal, muscle tension, and promotes feelings of calmness and relaxation (Bernstein & Borkovec, 1973).

Relaxation can also support the development of greater self-awareness, improve responses to stressful situations, and help individuals develop more effective coping strategies for managing anger situations (Hazaleus & Deffenbacher, 1986). In addition, relaxation reduces heart rate and blood pressure, which can reduce the experience of anger and hostility (McGuigan & Lehrer, 2021).

This meta-analysis also found that the effectiveness of anger-management activities improved when both cognitive and arousal-decreasing components were implemented, compared to only the arousal component. Many arousal-decreasing activities include cognitive components. For example, meditation and mindfulness increase a sense of connection, compassion, and empathy for others, as well as the ability to regulate emotions (e.g., Fix & Fix, 2013; Hölzel et al., 2011). Mindfulness has also been found to reduce physiological indicators of anger, such as heart and respiratory rate and blood pressure (Fennell, Benau, & Atchley, 2016). Researchers have argued that mindfulness and meditation can improve emotional tolerance and reduce the need to express anger as a way of controlling it (Rahrig et al., 2021). This supports Schachter and Singer's (1962) theory.

In studies that used arousal-increasing activities, outcome measures of anger, hostility, and aggression were all nonsignificant. However, the effects were heterogeneous. The type of physical activity impacted outcomes. Jogging, in particular, elevated anger. This may be because jogging involves repetitive movements, which can be monotonous and lead to boredom or frustration, increasing the likelihood of experiencing anger (Linden, Earle, Gerin, & Christenfeld, 1997; van Hooft & van Hooft, 2018). Some individuals may also feel like they have less control during jogging exercises, such as when they are on a treadmill, which may lead to feelings of anger (Bartholomew, Morrison, & Ciccolo, 2005; Salmon, 2001). In contrast, ball sports (i.e., soccer, volleyball), physical education classes (e.g., group sports and games), and aerobic exercise (e.g., different types of cardio combined) decreased anger. This could be because both ball sports and physical education classes include play, which elicit positive emotions (Kottman, 2013; Singer & Singer, 1990). However, further research is needed to fully understand the mechanisms underlying the relationship between type of exercise and anger.

Contrary to predictions, state anger measures did not significantly differ from trait anger measures. However, more research is needed to explain this finding.

9.3. Exploratory moderators

For source characteristics, effects were stable over time, regardless of whether studies used activities to decrease or increase arousal. The effects from published and unpublished studies did not differ. Unfortunately, few studies were preregistered. We encourage anger-management researchers to preregister their studies.

For participants characteristics, gender and age did not moderate the effect size of arousal-decreasing or arousal-increasing activities on anger and aggression. However, samples with more White participants reported being angrier after arousal-increasing activities. This suggests there may be race differences in the interpretation of arousal, although the race differences might be due to other variables. Participants from individualistic cultures were also noticeably angrier following arousal-increasing activities than participants from collectivistic cultures. This may be because the anger regulation strategy in collectivistic cultures is more often to suppress than express angry feelings (Denson & Fabianson Tan, 2023). Students were also considerably angrier after arousal-increasing activities than were non-students. This may be because students experience higher levels of stress and anxiety in their everyday lives than others (Meeks, Peak, & Dreihaus, 2023). However, more research is needed to determine the reason for these findings.

Criminal offenders benefit as much as non-offenders from arousal-decreasing activities. Similarly, people with intellectual disabilities benefit as much as people without intellectual disabilities from arousal-decreasing activities. This may be because physiological arousal

responses are universal and not directly related to cognitive ability (Jones, Hastings, Totsika, Keane, & Rhule, 2008). Thus, activities that aim to decrease physiological arousal may be effective in reducing anger in clinical populations. There were not enough samples to examine these moderators for studies that used arousal-increasing activities.

In studies with arousal-decreasing activities, there was no significant difference in outcomes between individual versus group sessions. The finding contradicts prior meta-analysis that found individual treatments to be more effective than group treatments (DiGiuseppe & Tafrate, 2003). The lack of difference between group and individual delivery of treatment could be because of other factors, such as the specific activities used or the characteristics of the specific sample. In addition, this meta-analysis included all ages, whereas DiGiuseppe and Tafrate (2003) only included adults. It could also be that individual treatments were once more effective than group treatments, but with advancements in group therapy techniques, group treatments may now be equally effective. However, it is difficult to draw definitive conclusions about the difference in results.

For study characteristics, participants were angrier after arousal-increasing activities when treatments were delivered by researchers than trained instructors and when activities were delivered individually than in group sessions. In contrast, participants were less angry after arousal-increasing activities that involved more rather than fewer sessions. This implies that individuals who regularly exercise may experience less anger than those who do not. However, to draw more definitive conclusions, longitudinal studies are needed. Differential attrition, the length of sessions, and treatment duration did not influence anger, regardless of whether studies used arousal-decreasing or arousal-increasing activities.

Some design characteristics influenced outcomes. In studies using arousal-increasing activities, implementing within-subject design considerably reduced anger. This could be because of bias in within-subject design, such as learning, contextual referencing, and other psychological factors (Charness, Gneezy, & Kuhn, 2012). However, more research is needed to explain this finding. The setting in which the study was conducted also had an impact. Specifically, for studies with arousal-increasing activities, the effect was significantly larger in laboratory settings than in field settings. Laboratory settings are more controlled, which may lead to stronger and more consistent effects (e.g., Anderson & Bushman, 2002; Mauss et al., 2012). The type of report also influenced outcomes. For studies that used arousal-decreasing activities, self-reports had larger effects than other reports. Self-reports are more sensitive to changes in internal states, such as emotions. In addition, other reports may be influenced by various factors such as observer bias and situational context.

9.4. Theoretical implications

The relationship between physiological arousal and anger is complex and is influenced by various factors. The finding that decreasing physiological arousal decreases feelings of anger supports the approach motivation theory of anger (Carver & Harmon-Jones, 2009), which suggests that anger is associated with the approach system and that individuals experience anger when goals are blocked or impeded. The findings also support the Schachter and Singer (1962) theory that both cognitive and physiological arousal components are important components of emotional experiences. In addition, the findings are consistent with appraisal theories of emotion (Lazarus, 1982; Lazarus, 1991; Moors et al., 2013). This meta-analysis contributes to our understanding of the relationship between physical activity and anger. Specifically, it highlights the importance of considering the type of physical activity and the role of both physiological arousal and cognitive processing in the experience of anger.

9.5. Practical implications

This meta-analytic review suggests that arousal reduction offers a good alternative or supplemental therapeutic modality to traditional cognitive-behavioral therapy. Relaxation, meditation, and mindfulness practices have become increasingly popular in healthcare settings over the past few decades (Ouwens, Boschloo, Speckens, & van den Brink, 2017). Many hospitals, clinics, and wellness centers offer mindfulness-based programs to help manage stress, pain, and other health conditions. This meta-analysis supports the notion that such activities can have significant benefits for mental health (Cafazzo, Casselman, Stacey, & Easty, 2012; Elkins, Fisher, Johnson, & Minden, 2016), including anger management. The findings also show that the effects are consistent across different populations, times, and situations.

Furthermore, the findings suggest that individuals seeking to improve their anger management skills may benefit from committing to long-term programs. Health professionals should consider incorporating these arousal-decreasing techniques into their treatment for people with high trait anger. Individuals who struggle with anger and hostility may benefit from relaxation techniques. They may also benefit from choosing activities that promote positive emotions, such as yoga and mind-body exercises.

Additionally, the findings suggest that although regular physical activity has many health benefits, it does not have anger management benefits. This review underscores the importance of considering individual differences in how physical activity affects anger, as well as the potential negative outcomes associated with certain types of physical activity.

9.6. Limitations

An important limitation of this meta-analysis is that several moderators could not be examined due to a lack of information reported in studies. For example, provocation may contribute to even more anger in combination with increased arousal, but not enough studies included provocation versus no provocation to test this hypothesis. Although several moderators were examined, there may be unknown moderators. For example, individuals with high trait anger may experience a greater reduction in their anger levels compared to those with lower trait anger (Veenstra, Bushman, & Koole, 2018). This is because individuals with higher levels of trait anger tend to have more room for improvement and may benefit more from activities that target their anger management skills. Therefore, future studies should consider trait anger as a potential factor when designing and implementing anger management activities.

In addition, it would be beneficial for future studies to explore the effectiveness of long-term activities, which would allow for comparison of effect sizes between short-term and long-term studies. Currently, the mean number of arousal-increasing session included in this meta-analytic review was 14.19 sessions. However, the results suggest that arousal-increasing activities lasting longer than this may be beneficial. Therefore, future research should aim to investigate the optimal number of activities to provide better guidance for clinicians and practitioners working with individuals with anger management difficulties.

Furthermore, most of the studies included in this meta-analysis used samples from individualistic countries (99.8% of studies that used anger-increasing activities and 76.9% of studies that used anger-decreasing activities). Most participants in these studies were from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies (Henrich, Heine, & Norenzayan, 2010), which limits the generalizability of the findings to other societies. Although the overall effect of decreased arousal anger management did not differ significantly between participants from individualistic and collectivistic countries, the former showed a descriptively smaller effect than the latter. To obtain a more comprehensive understanding of anger management, studies need to be conducted in diverse geographical locations, including Africa, South America, and Asia.

Similarly, the studies included in this meta-analysis were limited to those published in English. This exclusion criteria resulted in most studies conducted in English-speaking populations, primarily from the USA and Europe.

Finally, the results from the sensitivity analysis indicate a considerable presence of publication bias and outliers among the moderators examined for studies that used arousal-increasing activities (see Supplemental Materials). This could be due to the diversity of the physical activities used in these studies (e.g., jogging, aerobics, weight training, martial arts) and the few studies representing each type of activity. This should be addressed by future research.

9.7. Conclusions

This meta-analytic review highlights the importance of physiological arousal in anger management. The findings suggest that decreasing physiological arousal can effectively decrease anger and aggression, whereas increasing arousal does not. Overall, these results underscore the value of incorporating physiological arousal reduction techniques, such as breathing, relaxation, meditation, yoga, and mindfulness into anger management programs. Effects were found for both group and individual treatments, trait and state anger measures, all types of reports, in both field and laboratory settings, in students and non-students, in criminal offenders and non-offenders, in participants with and without intellectual disabilities and in all genders, races, and ages. The results were also stable across the years examined. These findings provide insight for researchers and practitioners on the characteristics to consider in designing anger management programs. In addition, the results shed light on the general misunderstanding that letting off steam or going for a run are effective anger management activities. It is much better to engage in activities that decrease arousal than activities that increase arousal.

Author notes

Sophie L. Kjærviik and Brad J. Bushman, School of Communication.

This meta-analytic review was based on the first author's doctoral dissertation at The Ohio State University. The first author is now a post-doctoral fellow in the Injury and Violence Prevention Program at Virginia Commonwealth University.

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Declaration of competing interest

None.

Data availability

<https://osf.io/u3vjn/>

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cpr.2024.102414>.

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