THE EFFECT OF BRAIN BREAKS ON STUDENT OUTCOMES OF SCHOOL-AGED CHILDREN IN K-12 CLASSROOMS: A META-ANALYSIS

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ABSTRACT

THE EFFECT OF BRAIN BREAKS ON STUDENT OUTCOMES OF SCHOOL-AGED CHILDREN IN K-12 CLASSROOMS: A META-ANALYSIS

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Integrated physical activity in the classroom has been shown to affect K-12 students' development positively. Students of all abilities benefit from multimodality learning. This study investigates the relationship between classroom brain breaks and school-aged students' classroom behaviors. The Meta-analysis search process consisted of 3 Phases: (1) Screen the titles, (2) Screen the abstracts, and (3) Retrieve the Full Text. Literature searches were conducted in eight electronic academic journal databases: SPORTDiscus, PsycINFO, PsycARTICLES, Cochrane Database, Web of Science/Web of Knowledge, ProQuest, Child Development and Adolescent Studies, and ERIC. Students (N) are enrolled in schools serving students from kindergarten through twelfth grade. The overall effect that brain breaks provided across all outcomes was small ($k = 56$, $g = 0.36$, 95% CI = 0.22, 0.50, $P < 0.001$) with large prediction intervals for each of the category outcomes that suggest a large degree of variability. Future research should consider the methods used to implement brain breaks by following specified guidelines that produce positive results for the intended outcomes being studied.

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INTRODUCTION

Educators are continually seeking ways to implement effective classroom management techniques that will decrease disruptive behaviors and increase/improve academic outcomes (Sieberer-Nagler, 2016). The school environment provides a context where students develop self-regulatory skills to manage their physical, emotional, and academic behaviors. Teachers and schools provide structure and accountability designed to reinforce desired academic outcomes. However, not all of the time schools provide a formal structured environment. During the informal and unstructured times, students use their behavioral self-regulation skills to navigate those positive and negative situations and interactions. Teachers develop and employ methods to support their students and facilitate positive academic outcomes. Various strategies have been developed in K-12 schools to help students succeed in their classrooms through increased engagement, focus, and behavior management skills (Tomlinson, 2012). Teachers might benefit from using new approaches to student success by providing the most academic and aerobic movement breaks throughout the school day (Fedewa et al., 2018). These movement breaks, also referred to as “Brain Breaks,” have recently become a popular tool for teachers to help their students improve their focus, engagement, and socially appropriate behaviors through fun movement activities (Baker et al., 2017).

Physical activity has been shown to positively influence cognitive performance and psychological health (Poitras et al., 2016). Research has found that physical activity levels decrease as children age. When combined with teaching methods that do not use physical activity to improve academic outcomes, opportunities are missed (Haapala et al., 2014). Although K-12 students have different ways to engage in physical activity, sedentary levels outweigh physical activity levels (Watson et al., 2017). Various strategies have been developed in K-12 schools to help students succeed in their classrooms regarding increased engagement, focus, and behavior management skills (Baker et al., 2017). Brain or movement breaks have recently become a popular tool for teachers to help their students improve their focus, engagement, and socially appropriate behaviors through fun movement activities that allow students to participate in physical activity in a classroom setting (Mazzoli et al., 2021).

Research has linked being sedentary for longer periods in classrooms to eye strains, spinal pressure, and decreased deep breathing, negatively influencing student attention and concentration (Morton, 2016). Increased sedentary levels in academic settings can show negative health-related issues, disruptive behaviors, and disengagement in learning (Juonola et al., 2013; Haapala et al., 2014; Väistö et al., 2014). Following a physical brain break, blood flow increases brain activity in students, allowing the brain to remain alert for learning (Erlauer, 2003). When students are allowed to move during a lesson, research has shown that they experience a decreased amount of physical fatigue and are better able to concentrate efficiently on concepts and tasks (Mok et al., 2020; Glapa et al., 2018; Kuan et al., 2019). Given these research findings, teachers can utilize movement during academic periods by implementing a brain break from instruction.

Brain Breaks Defined

Research on student engagement patterns has studied how teaching methods and student activities improve student outcomes and achievement (Magennis and Farrel 2005, Cianciolo 2006). One such method frequently studied in literature is instant activity, also known as brain break (Bobe et al., 2014). Brain breaks involve physical activity to activate the information processing areas of the brain by changing the routine of incoming information to the prefrontal cortex, where problem-solving and emotional regulation occurs (Mazzoli et al., 2021). While numerous methods and definitions have been used to specify brain breaks, the definition that focuses on the current investigation includes a teacher-initiated short-term and intermittent strategy or method to engage students in an activity designed to increase physiological arousal and shift students from sedentary to active mode (Mok et al., 2020). Research that has been conducted using these types of physiological methods has found that several student outcomes such as on-task behavior, academic achievement, and overall physical and emotional health are improved by student participation (Esteban et al., 2015). When the body is engaged in some form of movement, the brain can refocus and stimulate neural pathways in the prefrontal cortex, where learning is linked to performance (Desautels, 2016).

Types of Brain Breaks

Educators have identified three categories of brain breaks that can be divided into activities attributed to breathing or relaxation, involving vigorous physical activity between portions of a lesson, and focusing on mental activity (Weslake and Christian, 2015). Breathing activities use one's breath as the focus point (Desautels, 2016). Due to the school day time constraints, teachers often choose to use breaks incorporating academic content and movement (McMullen et al., 2014). Mok (2020) uses iPads and YouTube so students can find their exercise videos as an individualized movement break. Elementary school students can easily participate in relaxation and stretching movements (Bobe et al., 2014).

Desautels (2016) lists a variety of Focused Attention Practices similar to Weslake and Chirstian (2015). These exercises are designed to quiet the thoughts, distractions, and frustrations that occur every day. The first practice is “Breathing,” which uses one's breath as the focus point. Desautels (2016) mentions various ways educators can teach and use breathing in their classrooms, such as having students hold a hand in front of their noses and the other on their stomachs. Connections are made to students by describing their belly growing with every inhale and feeling the warm air of every exhale. Another form of breathing we can use as a brain break is “The Deep-Dive Breath,” where students inhale for four to five seconds, hold for 4 to 5 seconds and then slowly exhale for 4-5 seconds. The “Energizing Breath” starts with 30 seconds of open mouth panting followed by 30 seconds of closed mouth belly breaths. The most common brain break is the one that deals with physical activity or “Movement.” Younger students can benefit from simple, fun commands, such as “shake your sillies out” or “do the worm with your arms.” Teachers can model the desired behavior they want to instill in their students (Desautels, 2016; Westlake and Christian, 2015). When a student sees a teacher participate in the movement, the student becomes motivated to participate. Finally, Desautel (2016) leaves us with the "Rise and Fall" method in which students watch items rise and fall on their stomachs while breathing in and out of their noses.

While high-intensity imagery-filled movements such as "shake your sillies out" or "do the worm with your arms" are effective for younger students, simple breathing exercises like holding a hand in front of one's nose and the other on their stomachs are universally appropriate across age groups and ability levels (Desautels, 2016). Elementary teachers often chose breaks that emphasized specific math and spelling skills (e.g., Math Wheel, Spelling in Motion, Frozen Words). Whereas "review" activities (e.g., Beach Ball Review, Medicine Ball Review, Around the World Review) were popular among high school teachers (McMullen et al., 2014). Activity breaks with academic integration were a characteristic that general education teachers frequently considered when selecting an activity break. In contrast, special education teachers have found that due to the range in cognitive abilities in a single special day class, simple movement-based activities are more successful (McMullen et al., 2014).

Timing of Brain Breaks

Frequency

Research that has studied Brain Breaks in classrooms recommends that they should be present in the classroom throughout the day (Janssen et al., 2014). While students can participate in unstructured activities such as recess, the imbalance of activity and sedentary behavior prevents students from maximizing cognition (Watson et al., 2017). Based on study findings, teachers can improve several student outcomes using brain breaks (Janssen et al., 2014; Howie et al., 2014; Carlson et a., 2015, Mead et al., 2016). Specific time periods listed in the literature include mornings immediately after classes begin, transition periods such as from lunch back to class, and near the end of the school day (Cline et al., 2021). The final consideration for when to implement brain breaks might include academic subject matter that requires intense concentration and focus on problem-solving activities. Overall, the frequency of brain breaks should consider the time of day, transition periods during the school day, the cognitive effort of subject matter, and changing student attitudes (Egger et al., 2019).

Duration

Teachers need to manage time spent on academic learning and implementation of brain breaks as shift and balance between sedentary and active behaviors is critical (Ma et al., 2014). Research that has been done on the duration of activity indicates specific time periods are more beneficial (Jensen, 2005). Implementing a 5-minute physical activity into the classroom routine proved to increase On-task behavior during academic lessons and overall physical activity throughout the day in school (Podnar et al., 2018). Studies have also found that when brain breaks are implemented for 10 minutes or more, student cognitive performance improves (Janssen et al., 2014; Daly-Smith et al., 2018; Howie et al., 2014). Another consideration would be specific age and developmental levels; for example, second to fourth-grade students showed improved on-task behavior after very brief, high-intensity exercise (Ma et al., 2014). Additional research on shorter periods has found that applying brain breaks from one minute to five minutes can improve academic retention and attention (Daly-Smith et al., 2018; Jensen, 2005). Transition time is another factor to consider; an activity may last five minutes, but depending on the activity, it could take 5 minutes to transition back to work from the break (McMullen et al., 2014). Brain Breaks provide an effective approach to fill time whenever students need a break from a lengthy lesson or during a transition period.

Brain Breaks and Student Behavior

The number of variables present in a learning environment that teachers need to consider and respond to ensure students meet the achievement and learning expectations. Studies have found that when students are sedentary for long periods, they are more likely to engage in disruptive behaviors such as eloping and verbal and physical outbursts that may harm others or damage equipment (Kariippanon et al., 2021). When teachers can track and identify student cues connected to disruptive behaviors, such as mental fatigue and stale cognitive processes, by integrating physical activity or movement breaks into lessons, students are more likely to meet and exceed the expectations (Turner and Chaloupka, 2017). One specific outcome important to student performance and learning is being able to attend, focus, and respond to the immediate task (Mavilidi et al., 2021). Attention plays a vital role in students' success as they can interpret the information provided promptly to complete the tasks assigned (Kariippanon et al., 2021). Research has found that positive outcomes include greater content retention, content recall can be accessed faster to respond favorably to the task, and transition between activities more efficiently when students are more attentive during a lesson (Guardino and Fullerton, 2010; Moon et al., 2020).

Attention and Focus

Research shows that students who participate in movement breaks during a lesson attribute to less disruptive behavior and show vast improvements in attention (Camahalan & Ipock, 2015; James-Burdumy et al., 2013). However, the literature has produced inconsistent findings to support the claim activity breaks always have a positive effect on cognitive functioning in students (Calvert et al., 2019; Daly-Smith et al., 2017). A more recent study shows students who participated in cognitively engaging active breaks improved response inhibition at the same rates compared to those in controlled conditions (Mazzoli et al., 2021). Another limitation of the brain break literature is the effect on females, as most studies have been conducted with male or mixed gendered samples (Ma et al., 2014). What is clear from the literature is the positive associations between brain breaks and attention to task, academic achievement, and academic behavior (Walker, 2017; Podnar et al., 2018). Also apparent from the research is that teachers report increased focus and engagement and decreased behavioral problems after introducing brain breaks (Baker et al., 2017). The physiological mechanism underlying this effect is that brain breaks help students be active in and outside the classroom. More information is needed to understand the specific parameters of use. While the evidence is inconsistent, specific studies on brain breaks have found that students who actively participated demonstrated positive behaviors in the learning environment (James-Brdumy et al., 2013; Chang and Coward, 2015). When students can engage in movement, they are less likely to display maladaptive behaviors that are counterproductive to desired outcomes such as learning and achievement (Moon et al., 2020).

Disruptive/Maladaptive Behavior

There are various ways to define disruptive/maladaptive behaviors. The research establishes maladaptive behaviors as aggression towards oneself or others that can affect learning (McDaniel and Flower, 2015; Purwati and Japar, 2017; Cholewa et al., 2010). Various forms of disruptive behavior that can take part in the classroom include: showing aggression towards oneself or others, screaming, disobeying, breaking class objects, getting attention, or raging (Schroder and Gorden, 2002). As mentioned above, the educational literature has consistently shown that classroom management strategies involving activity can be used as preventative measures for both mild and severe disruptive behaviors (Guardino and Fullerton, 2010). Classroom management strategies that facilitate effective brain breaks mirror specific components of universal design for learning, such as modeling, use of visuals, and pre-teaching (Johnson-Harris and Mundschenk, 2014). While the focus and intent between classroom management and brain breaks might differ, the outcomes are similar and suggest that students are more positively engaged and on task (Cline et al., 2021). Data shows second to fourth-grade students with a history of maladaptive behaviors were observed to improve off-task behavior after very brief high-intensity bouts of exercise (Ma et al., 2014). There are distinct parallels between classroom management strategies and brain breaks as they improve attention/focus, disruptive behavior, student engagement, and increased time on task (Yassine et al., 2020).

Strategies to Implement Brain Breaks

Implementing brain breaks in the educational setting has to take a strategic approach, and different ages and developmental levels respond differently. Classroom environmental modifications can be incorporated throughout the day to help neurotypical and neurodivergent students obtain and maintain optimal attention for learning (Bateman, 2018). Kindergarten teachers who implement direct, intentional, and focused feedback strategies with high levels of teacher support see positive increases in students' time on task and academic engagement (Pianta et al., 2002). Behavior-specific social praise is an empirically supported classroom management practice at the elementary level (Briere et al., 2015). According to the literature, elementary teachers should use technology (Brain Break video) as results suggest student improvements in physical activity attitudes and cognitive performance (Cline et al., 2021). Fewer research studies have been conducted on secondary students (High School), and findings showed no improvements in academic performance after implementing a brain break video (Maddox, 2019; Donner, 2013). When brain breaks were administered to students with disabilities involving a stability ball, there were significant improvements in student classroom behavior (Schilling and Schwartz, 2004; Bagatell et al., 2010; Schilling et al., 2003). Comparatively, typically developing students in math classrooms can see benefits in cognitive performance using stability balls (Mead et al., 2016).

The relationship between teachers and their students is a significant factor in reducing behavioral concerns among students in the classroom (Yassine et al., 2020).

Teachers should model the desired behavior that they expect their students to demonstrate (Desautels, 2016). Teacher participation in the movements motivates students to participate (Westlake and Christian, 2015). While some believe the impact of teacher behavior in the relationship between classroom movement breaks and student outcomes has not been researched thoroughly (Fedewa et al., 2018), the classroom climate created by a teacher impacts their student's sense of involvement, emotional closeness, and support (Pianta et al., 2002). Six scaffolding strategies effective teachers use during brain breaks are: Show and Tell, Tap into prior knowledge, Give time to talk, Pre-teach vocabulary, Use visual aids, and Pause, ask questions, pause, and review (Alber, 2014). Some factors must be considered when implementing break breaks; most notable teachers should consider experimenting with different brain breaks according to research parameters (Baker et al., 2017).

Statement of the Problem

Research conducted on Brain Breaks using moderate to vigorous physical activity has found positive benefits across several student outcomes. Previous studies that have attempted to synthesize the existing literature have provided some qualitative and qualitative information related to the overall effectiveness of Brain Breaks on student achievement and successful outcomes. What is not clear from these previous studies are the moderating effects of several different independent variables related to school and student characteristics. Therefore, the purpose of the current investigation was to conduct subgroup (moderator) analyses to determine if Brain Breaks were more effective for specific (school and student) population characteristics.

METHODS

Comprehensive Literature Search

Search strategies were developed using keywords determined by the author (Moher, Liberati, Tetzlaff, Altman, & Prisma Group, 2009). The main keywords used in journal article databases include the following: brain breaks, movement, movement breaks, activity breaks, disruptive behavior, maladaptive behaviors, behavior therapy, physical activity, adapted physical activity, classroom, school, education, adapted physical education, and physical education. Combinations of these keywords identifying the condition (brain/movement breaks, etc.) and setting/context (adapted physical activity, classroom, etc.) were entered into several academic databases that include: SPORTDiscus, ERIC, PsychINFO, PubMed/Medline, Child Development, and Adolescent Studies, Proquest, and PsychARTICLES. A three-stage screening process was implemented during this analysis. In the first stage, two authors conducted initial searches utilizing the main keywords. During the first phase, screening titles were based on the relevant keywords in accordance with the context of this study, the authors saved the article's citation to a citation program (EndNote X7), and after completing initial searches, all duplicates were removed. In the second stage, the articles from all databases were independently screened by two authors according to titles and abstract review. If the abstract did not provide sufficient information or was considered unrelated to the study focus, it was excluded from this study. In the third stage, two authors independently retrieved the remaining articles in full-text form. If an article does not provide sufficient information meeting inclusion criteria during the review of full texts, the lead author was contacted requesting the missing information.

Inclusion Criteria

Inclusion criteria were implemented to determine if the authors saved articles during the initial screening. The inclusion of this analysis was: (a) the study took place in a physical education setting (PE), physical activity (PA), classroom, or school setting; (b) the participants of the study were five to eighteen (5-18) years of age; (c) the study included movement as means to improve student outcomes, (d) the study had a quantifiable measure outcome that would allow the calculation of effect size; (e) the study was written in the English language; (f) the study was published after the year of 1970.

Definitions of Settings

To define the settings extracted from included studies, a physical education (PE) setting was determined as an activity taking place in an educational setting during school hours. Physical Activity (PA) settings were defined as activities outside a school setting. Classroom settings were defined as in-room during academic curricula. Adapted physical activity was an educational setting that used accommodations and modifications during activity.

Study Coding and Data Extraction

Coding and data extraction forms were developed using established protocols (Brown, Upchurch, & Acton, 2003). Study information was separated into categories: methodological characteristics, sample characteristics, and study characteristics. Methodological characteristics included study design (descriptive or experimental), the duration of break (< 2 minutes, 2-5 minutes, OR > 5 minutes), brain break type (aerobic, anaerobic, or other), brain break frequency days/week (1 day, 2-3 days, > 3days), brain break setting (classroom, outside, physical education), brain break outcome (academic, behavior, physical). Sample characteristics included Age (elementary school, middle school, high school), Gender (female, Male, OR Both), Country/Location (US, Europe, OR Asia), Sample Size (single class, multiple classes, school), Developmental Level (Disability, Typically Developing, OR Both), Study Characteristics included Publication Status (Published OR Unpublished), Funding Status (Grant Funded, Unfunded, OR Not Reported), Outcome Measurement (Subjective OR Objective).

Outlier Analysis

Outliers were considered to be studies two standard deviations above or below the overall mean effect of the meta-analysis. Studies were considered to be outliers if the residual scores ((z-score >± 1.96) for that study were outside the ninety-fifth percentile of the mean effect score. If an outlier was present in the data, a sensitivity analysis was performed using a “one study removed” technique in Comprehensive Meta-Analysis

Software (CMA). The one study removed procedure recalculates the meta-analytic statistics to determine the overall results if a study were to be removed. The decision to include a study was based on unchanged results (marginal influence on the effect size and associated p-value) and within a 95 percent confidence interval. Outliers were retained if the results remained significant ($P < 0.05$) and within the 95% confidence interval.

Publication Bias

Publication Bias was considered to be the influence of published or unpublished studies not identified or included during the literature search or screening process. Three procedures were used to screen for publication bias that included a "Trim & Fill" method, Begg and Mazumdar rank correlation, and Egger's Regression Intercept. The funnel plot uses standard error (y-axis) and effect size (x-axis) to see if the plot is symmetrical. Each of the three procedures is used to determine asymmetry and the potential influence of studies that are missing.

Effect Size Calculations

Comprehensive Meta-Analysis (CMA) version 3 software was utilized to calculate effect size statistics (Borenstein, Hedges, Higgins, & Rothstein, 2009). Hedges's g was the effect size metric used for the analysis to adjust for effect size inflation based on smaller study sample sizes, given the variability across the outcomes being reported (Hedges, 1981). Data that was extracted from included studies used mean (M), sample size (N), and standard deviation (SD) as the primary methods for effect size calculations. If this data was unavailable, additional statistics such as F-values, t-values, and/or P-values from each study were extracted (Rosenthal, 1994). A random-effects approach was used to model error for the current meta-analysis (Borenstein, Hedges, Higgins, & Rothstein, 2009). A random effects model used sampling error and between study variance to estimate the effect size. When several outcomes were extracted, the study was the unit of analysis, and a procedure was used that averaged the outcomes for a single effect size calculation (Borenstein, Hedges, Higgins, & Rothstein, 2009).

Heterogeneity of Variance

Four statistics were used to evaluate heterogeneity and provide a comprehensive approach to interpreting results. The prediction interval quantifies how much studies varied, the QTotal (QT) value based on χ-square (χ2) distribution reports if studies share the same effect size, tau-squared (τ2) value provides the variance of true study effects, and I-squared (I2) value indicates provides the proportion of the variance that between observed and true effects. Significant QT statistics have been categorized into QBetween (QB) and QWithin (QW) values and significant QB values ($p < 0.05$) require statistical techniques to determine subgroup differences.

RESULTS

The primary purpose of the current study was to investigate the influence between classroom brain breaks and students' classroom behaviors and academic performance. Studies in the current investigation focused on how the use of activity breaks affected student outcomes in academic contexts, which included executive functioning, maladaptive behaviors, and physical activity. Academic outcomes data was gathered from studies that reported classroom scores in Spelling, Math, Reading, and Science and academic assessments such as the National Curriculum Level progress and the Measures of Academic Progress (MAP). Executive functioning outcomes were measured using variables such as working memory and attention, with the Stroop test being used as the predominant instrument to measure executive functioning. Physical activity looked at the percentage of time and intensity of activeness throughout the school day. The behavior outcomes reviewed total time on task and off task data which were reported as behavior frequency and duration data.

Search procedures initially generated 12524 potential studies for evaluation. Decisions regarding article retrieval were based on full-text reviews of 250 studies. There were a total of 56 studies included in the current investigation that met inclusion criteria. Overall, the inter-rater agreement between the two coders was high during the search process ($\kappa = 0.76$ to 0.92) across the literature screening, subgroup characteristics coded, and extraction of descriptive and inferential statistics. When interpreting the treatment effects, Cohen’s (1988) criteria were used for the interpretation of standardized mean differences and summarized effect sizes as small (0.2), medium (0.5), and large (0.8). Positive effect sizes are interpreted as Brain Breaks improving student outcomes compared to control conditions or groups. Negative effect sizes were considered a decrease in student outcomes and were not influenced by Brain Breaks. When an outcome showed a decrease considered to have improved performance, the effect size was classified as positive. For example, reaction time is an outcome in which improvements (decreases in time) would be considered positive. All such outcomes were coded as positive to represent an accurate interpretation of the result.

Table 1 Methodological Characteristics (MC), Sample Characteristics (SaC), and Study Characteristics (StC)

MC	MC	MC	MC	MC	MC	SaC	SaC	SaC	StC	StC	StC	StC
Study	Design	Time	Type	Frequency	Setting	Level	Gender	Country	N	Measurement	Fund	Status
Zhou et al., 2016	E	2-5	M	3	C	ET	B	China	780	S	U	P
Adaland et al., 2018	E	2-5	O	3	C	ET	B	Norway	1202	C	U	P
Alhassan et al., 2018	E	5	M	3	C	ET	B	US	291	O	U	P
Baker 2005	E	2-5	M	3	C	ED	B	US	20	S	U	U
Bartholomew et al. 2018	E	5	AL	3	C	ET	B	US	2716	O	U	P
Buchele Harris et al. 2018	E	5	M	3	C	ET	B	US	109	O	U	P
Chancey 2019	E	5	O	2	PE	EMHC	B	US	77	C	P	U
DiBitetto 2016	E	5	AL	3	C	MC	B	US	148	O	U	P
Donnelly et al. 2017	E	5	AL	3	C	ET	B	US	584	O	U	P
Egger et al. 2019	E	5	M	3	C	ET	B	Switzer	142	O	U	P
Egger et al. 2018	E	5	M	NR	C	ET	B	Switzer	216	O	U	P
Fedewa et al. 2015a	E	5	O	NR	C	ET	B	US	67	C	U	P
Fedewa et al. 2015b	E	5	Ae	3	C	ET	B	US	460	O	U	P
Fedewa et al. 2018	E	2-5	M	NR	C	ET	B	US	466	O	U	P

MC	MC	MC	MC	MC	MC	SaC	SaC	SaC	StC	StC	StC	StC
Study	Design	Time	Type	Frequency	Setting	Level	Gender	Country	N	Measurement	Fund	Status
Fiorilli et al. 2021	E	5	M	NR	C	ET	B	Italy	141	C	U	P
Glapa et al. 2018	E	2-5	M	3	C	ET	B	Poland	326	S	U	P
Goffreda 2011	E	5	M	NR	C	ET	B	US	127	S	U	U
Goh 2017	E	5	M	3	C	EMT	B	US	136	O	U	P
Goh et al., 2016	E	5	M	3	C	ET	B	US	210	S	U	P
Balasekaran et al. 2021	E	2-5	M	3	C	ET	B	Singapore	113	S	U	P
Graham et al. 2021	E	5	M	3	C	MT	B	Canada	116	C	U	P
Helgeson 2014	E	5	M	3	C	MT	B	US	130	O	U	U
Howie et al. 2015	E	5	Ae	3	C	EMT	B	US	96	O	U	P
Huddleston 2017	E	2-5	M	2	C	ET	B	US	38	O	U	U
Janes 2021	E	5	M	3	C	ET	B	US	22	O	U	U
Janssen et al. 2014	E	5	M	NR	PE	ET	B	Netherlands	123	O	U	P
Kubesch et al. 2009	E	2-5	Ae	NR	C	MT	B	Germany	81	O	U	P
Macdonald et al. 2021	E	5	O	3	C	ET	B	Australia	64	O	U	P
Mavilidi et al. 2020	E	2-5	M	2	C	ET	B	Australia	87	C	U	P
Mavilidi et al. 2021	E	5	M	3	C	ET	B	US	560	O	U	P

MC	MC	MC	MC	MC	MC	SaC	SaC	SaC	StC	StC	StC	StC
Study	Design	Time	Type	Frequency	Setting	Level	Gender	Country	N	Measurement	Fund	Status
Mawar Siti Hajar et al. 2019	E	2-5	M	3	C	ET	B	Malaysia	335	S	U	P
McClelland et al. 2015	E	<2,2-5	M	3	C	EMT	B	UK	348	O	U	P
Mead et al. 2016	E	2-5	O	NR	C	MT	B	US	71	O	U	P
Nixon 2008	E	NR	M	3	C	ET	B	US	22	O	U	U
Norris et al. 2018	E	5	M	2	C	ET	B	London	264	O	U	P
Nussbaum 2010	E	5	M	2	C	MH	B	US	364	O	U	U
Popeska et al. 2018	E	2-5	M	3	C	ET	B	Macedonia	238	S	U	P
Raney et al. 2017	E	<2	M	3	C	ET	B	US	114	C	U	P
Schmidt et al. 2016	E	5	M	2	C	ET	B	Switzerland	98	O	U	P
Snyder et al. 2017	E	5	AL	NR	C	ET	B	US	24	O	U	P
Szczasny 2016	E	NR	M	3	C	ET	B	US	76	O	U	U
Taylor 2010	E	2-5	M	3	C	EC	B	US	155	O	U	U
van den Berg et al. 2019	E	5	M	3	C	EMT	B	Netherlands	512	O	U	P
Osdol et al. 1974	E	5	O	3	C	ED	B	Australia	26	O	U	P
Vazou et al. 2017	E	5	AL	3	C	ET	B	US	124	C	U	P

MC	MC	MC	MC	MC	MC	SaC	SaC	SaC	StC	StC	StC	StC
Study	Design	Time	Type	Frequency	Setting	Level	Gender	Country	N	Measurement	Fund	Status
Watson-Grace et al. 2020	E	5	O	2	O	MT	B	US	28	C	U	P
Ahamed et al. 2007	E	5	M	3	C	ET	B	Canada	288	C	U	P
Cole et al. 2008	E	5	AL	NR	C	ET	B	US	128	C	U	P
Goh 2017	E	5	M	3	C	ET	B	US	137	O	U	P
Hunter et al. 2014	E	5	M	3	C	ET	B	Australia	107	C	U	P
Ma et al. 2014	E	2-5	M	3	C	ET	B	Canada	44	O	U	P
Mead et al. 2016	E	2-5	M	3	C	MT	B	US	81	O	U	P
Mullender et al. 2015	E	5	AL	2-3	C	EC	B	Netherlands	86	C	U	P
Mullender et al. 2015	E	5	AL	2-3	C	ET	B	Netherlands	228	C	U	P
Reed et al. 2010	E	5	M	2	C	ET	B	US	155	O	U	P
Roman et al. 2018	E	5	M	1	C	ET	B	Spain	96	O	U	P
Wilson et al., 2016	E	5	M	2-3	O	ET	M	Australia	58	O	U	P

Note. Design = Research Design. D = Descriptive or E = Experimental; Time = Brain Break Time Period, <2 = Less than 2 minutes, 2-5 = 2 to 5 minutes, >5 = Greater than 5 minutes, AL = Active Lesson.; Type = Type of Brain Break. Ae = Aerobic, An = Anaerobic, O = Other, or M = Mixed; Frequency = Brain Break Frequency. 1 = 1 day/week, 2 = 2 to 3 days/week, 3 = More than 3 days per week; Setting = Setting of Brain Break. C = Classroom, O = Outside, or PE = Physical Education; Level = Developmental & School Levels. E = Elementary, M = Middle School, H = High School, T = Typically Developing, D = Disability, C = Combined. Gender = Sample Gender. F = Female Only, M = Male Only, B = Both Male and Female; Country = Study Location; N = Sample Size. Measure = Outcome Measures; O = Objective Measures Used, S = Subjective Measures Used, C = Both Objective and Subjective Measures Used. Funding = Funding Status; F = Funded and U = Unfunded. Status = Publication Status; P = Published and U = Unpublished

Outliers and Publication Bias

Six studies were identified as outliers (Ahamed et al. 2007, z = -2.59; Mavilidi et al. 2021, z = 1.97; van den Berg et al. 2019, z = 2.03; Snyder et al. 2017, z = 2.44; Raney et al. 2017, z = 3.95; Huddleston 2017, z = 4.50); therefore, a sensitivity analysis (one-study removed process in CMA) was conducted to determine outlier inclusion or exclusion. The sensitivity analysis revealed that the overall effect size (g = 0.35, 95% CI = 0.21, 0.49, P < 0.001) would have remained the same with results and interpretation. Considering these criteria, all outliers were retained in analyses.

Publication bias was evaluated using the funnel plot, Trim and Fill procedure, Begg and Mazumdar's rank order correlation (Begg & Mazumdar, 1994), and Egger's regression intercept (Egger et al., 1997). Initial observation of the funnel plot revealed an asymmetrical distribution on the right side of the funnel plot. The Trim and Fill procedure used a random effects model to confirm symmetry as the funnel plot added no studies, and the results were unchanged (g = 0.35, 95% CI 0.21, 0.49, Q = 876.3). The Begg and Mazumdar rank order correlation was significant (P < 0.001), indicating that smaller studies may have contributed more to the overall results. However, Egger's regression intercept was insignificant (P = 0.68). The combination of these analyses revealed a potential "small study effect" indicating that the addition of potential studies may decrease overall effect size estimates (Sterne et al., 2011).

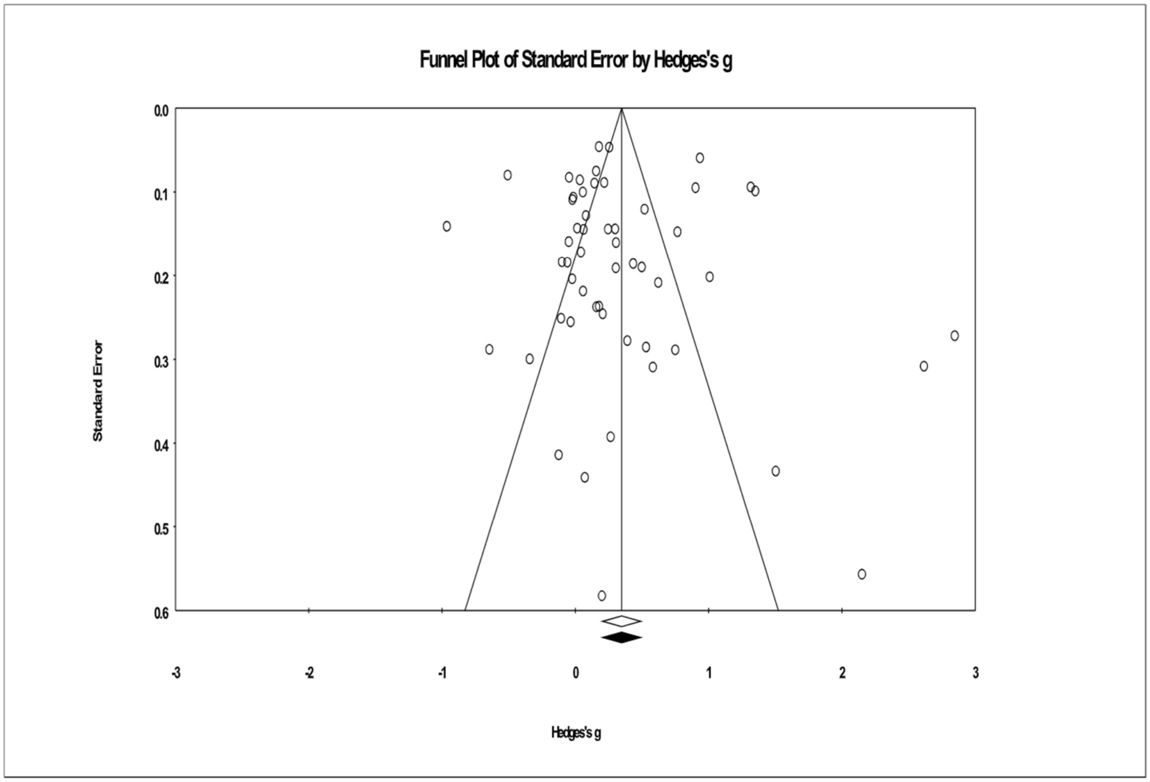

Figure 1 Funnel Plot of Standard Error by Hedges's g

Overall Results

The random effects model calculations were interpreted as an overall small effect (k = 56, g = 0.36, 95% CI = 0.22, 0.50, P < 0.001) for the influence that Brain Breaks have across student outcomes. Heterogeneity statistics suggest variability between studies in academic performance (QT = 1970, τ2 = 1.21, and I2 = 98.63), behaviors (QT = 424.26, τ2 = 0.50, and I2 = 96.23), executive functioning (QT = 229.99, τ2 = 0.26, and I2 = 95.22), and physical activity (QT = 304.51, τ2 = 0.22, and I2 = 97.04) and overall prediction intervals (-1.88, 2.72; -1.04, 2.08; -0.88, 1.50; -0.70, 1.58) suggested that Brain

Breaks will have distributed effects (ranging from no effects to large effects) on academic performance, physical activity, executive functioning, and behavior across comparable studies.

Outcomes Analyses

When conducting a meta-analysis, smaller sample sizes have been found to inflate effect size estimates requiring a correction for analyses to control for these increased estimations (Hedges, 1981; Borenstein & Hedges, 2019). Additionally, smaller sample sizes are likely to produce imprecise estimates of effect (Borenstein et al., 2019), and a minimum of 10 studies is needed to ensure an analysis provides meaningful and robust results (Borenstein et al., 2019; Higgins & Green, 2008; Trikalinos, 2007; Sterne et al., 2011). Given that smaller sample sizes influence the interpretation of results, therefore, the authors have selected to report outcomes that meet the minimum requirements and provide descriptive and conservative estimates of results that make recommendations for future studies (see discussion and conclusions).

A total of four student outcomes were collected from studies on school-aged children in general and special education populations that included academic performance, executive functioning, physical activity, and behavior. Effect sizes for academic performance ($k = 28$, $g = 0.42$), executive functioning ($k = 12$, $g = 0.31$), and physical activity ($k = 10$, $g = 0.44$) were small with behavior having ($k = 17$, $g = 0.52$) a moderate effect. Prediction intervals for each of these outcomes suggest that results are variable and inconsistent across studies of comparable size.

Table 2 Brain Break Outcomes: Effect Size Statistics (ESS), Null Test (NT), and Heterogeneity Statistics (HS)

	ESS	**ESS**	**ESS**	**ESS**	**ESS**	**NT**	**NT**	**HS**	**HS**	**HS**	**HS**
Variable	***k***	***g***	***SE***	s^2	**CI**	**Z**	**P**	**PI**	***Q***	τ^2	I^2
Academic Performance	28	0.42	0.21	0.45	0.01, 0.84	1.97	0.05	-1.88, 2.72	1970*	1.21	98.63
Maladaptive Behaviors	17	0.52	0.19	0.04	0.16, 0.89	2.81	0.01	-1.04, 2.08	424.3*	0.50	96.23
Executive Function	12	0.31	0.16	0.02	0.00, 0.61	1.96	0.05	-0.88, 1.50	230.1*	0.26	95.22
Physical Activity	10	0.44	0.15	0.02	0.14, 0.74	2.85	0.00	-0.70, 1.58	304.5*	0.22	97.04

DISCUSSION

The purpose of this study was to assess the effect of Brain Breaks in school-based education settings to improve skill-related outcomes for individuals with and without disabilities. The current investigation defines Brain Breaks as a teacher-initiated short-term and intermittent strategy or method to engage students in an activity designed to increase physiological arousal and physical activity (Mok et al., 2020). The prediction interval indicates a wide variability in studies on activity breaks suggesting that activity breaks range from highly effective to ineffective. Given the large between study variance and large sampling error, several factors such as age, ability/developmental levels, and genders need to be considered when implementing activity breaks.

Academic Outcomes

Academic outcomes related to students' achievement across several subject matter curricular areas such as Math, English, Reading, Spelling, and Science were studied. The current investigation found that academic performance through school subjects was measured using grades and/or standardized test scores. Across the 28 studies that reported on students' academic performance from brain breaks, there was a small positive effect, and were interpreted as groups receiving activity breaks increasing academic performance in core curricular subjects. The confidence interval was positive (CI = 0.01, 0.84); however, the large variability suggests that movement breaks may be effective but require further study of methods and types of brain breaks that may produce improvements in academic outcomes.

One factor that may influence the use of brain breaks relates to how teachers perceive the costs and benefits due to the school day time constraints (McMullen et al., 2014). Another factor that should be considered is teacher implementation and protocols. Teachers that have positive perceptions may develop and enhance routines to incorporate the benefits of using brain breaks when compared to teachers with negative perceptions (Webster et. al, 2017). Another factor that may produce variable results was the focus and purpose of how brain breaks were used concerning the academic content being delivered (Egger et al., 2019). Teachers who have demonstrated success with brain breaks suggest regular breaks in their daily schedule, specifically during natural movement times like transitions (Webster et al., 2017). Differences in the current investigation found that elementary teachers often chose breaks that emphasized specific daily learning goals, while “review” activities were commonly used by high school teachers (McMullen et al., 2014). Overall, research that has studied the uses of brain breaks suggests that the most effective physical activity interventions to improve children’s and adolescents’ academic achievement and classroom behaviors are curriculum-based (Alvarez-Bjueno et al., 2017).

Another consideration when implementing brain breaks is students' developmental level, as general education teachers were more likely to consider academic brain breaks as favorable compared to special education teachers who have found them challenging or ineffective due to their students’ range in cognitive abilities (Mazzoli et al., 2021). Research has found that teachers report using simple movement-based activities produces successful results, and training teachers on how to incorporate simple activities (i.e., brain breaks) would improve student outcomes such as increased focus, engagement, and enjoyment (McMullen et al., 2014, Webster et al., 2017). The use of brain breaks might also consider specific academic subjects being taught to ensure that positive results are obtained (Watson et al., 2017; Alvarez-Bjueno et al., 2017). Previous research has found that students' cognitive outcomes may differ as the mathematical performance was enhanced more with aerobic-based brain breaks while other subjects such as spelling and reading performance were not improved (Egger et al., 2019). Opposing research has found that brain breaks have little to no effect on math or reading scores (Szczasny, 2016). Possible explanations for the variability of brain break findings may be explained by differing methods, including study duration and data collection frequency (Popeska et al., 2018; Donnelly et al., 2017; Balasekaran et al., 2021; Mahar, 2011). Some studies were conducted using a same-day pre/post-test comparison, while others looked at semester and year-end grades. Finally, student achievement was reported differently as some studies used teacher-reported grades, and in other studies, standardized scores were the assessments used to measure academic performance. Standardized scores have been proven reliable; however, grades are problematic because teachers have different grading methods (i.e., rubrics, etc.) to determine higher quality work or performance that may lead to subjective evaluation (Finn et al., 2020; Hiibner et al., 2020).

Executive Functioning Outcomes

Executive functioning outcomes are students' ability to attend and focus promptly to complete a task(s) (Keenan et al., 2019; Vasquez III & Marino, 2021). Many studies measuring executive functioning used either the D2 Test of Attention or the Stroop test as outcome measures. The executive functioning outcome produces a small effect (g = 0.31), meaning the results are significant. The confidence interval tells us that it is positive (CI = 0.00, 0.61) for our current studies. However, for comparable studies that the authors may have missed, movement breaks may be highly effective for improving executive functioning, or they might not.

Students need to be able to attend to learn, and movement lessons have shown vast improvements in students' attention (Camahalan & Ipock, 2015; James-Burdumy et al., 2013). The current investigation found a positive effect between brain breaks and executive functioning; cognitive functioning increased after a short movement break (Jansenn et al., 2014; Daly-Smith et al., 2018; Howie et al., 2014; Alvarez-Bjueno et al., 2017). In another study, over half of the teachers interviewed agreed not only are brain breaks feasible to implement, but they also improve students' ability to focus (Webster et al., 2017, Perera et al., 2015). However, the literature has produced inconsistent findings (Calvert et al., 2019; Daly-Smith et al., 2017). A recent study found students who participated in cognitively engaging active breaks improved response inhibition at the same rates compared to those in controlled conditions (Mazzoli et al., 2021). Compared to the control, intervention students showed significant improvements in cognition skills only after engaging in a break with cognitive elements (Schmidt et al., 2016). Another factor that should be considered is age. There is a discrepancy between the number of studies with elementary-aged participants and high school-aged students. Further research is needed on the effectiveness of movement breaks in executive functioning for adolescents.

Behavior Outcomes

Brain breaks had a moderate effect on behavioral outcomes such as time on task. However, given the variability of the confidence interval, the use of brain breaks may or may not be effective. In school contexts, behaviors such as on and off-task engagement in the classroom are observable and have a predictable and measurable effect on learning (McDaniel and Flower, 2015; Purwati and Japar, 2017; Cholewa et al., 2010). The literature has consistently shown incorporating physical activity can be used as a preventative measure against disruptive behaviors ranging from minimal to severe (Guardino and Fullerton, 2010; Nussbaum, 2010). Research has found that the duration, as well as the type of brain break, might be able to explain this variability (Schmidt et al., 2016). Studies on typically developing elementary-aged students have shown that implementing a 5-minute or 10-minute physical activity into the classroom routine improved on-task behavior (Podnar et al., 2018; Goh et al., 2016). However, brain breaks lasting 3 - 5 minutes have proven to be successful for elementary students with one or more disabilities (Mazzoli et al., 2021). The current investigation found most studies (39) used a mixture of aerobic, anaerobic, and other types of brain breaks. Previous studies found that brain breaks with strictly physical activity did not affect elementary-aged students' outcomes, while brain breaks that were cognitively engaging proved to increase students processing speed and ability to focus and attend (Schmidt et al., 2016). In a recent survey, special education teachers reported students' behavior is one of the main barriers to implementation and suggested using brain breaks that include more calming activities depending on children's specific needs during the school day (Mazzoli et al., 2021).

Furthermore, the current investigation found that only two studies focused on high school students' on-task behavior, requiring additional evidence to understand how brain breaks influence older students' outcomes (Chancey, 2019; Nussbaum, 2010). Overall, students who actively participated in movement breaks demonstrated positive behaviors in the learning environment, including being positively engaged and on task (Moon et al., 2020; Yassine et al., 2020; James-Brdumy et al., 2013; Nussbaum, 2010).

Physical Activity Outcomes

The literature related to physical activity in school-aged children and adolescents continues to suggest there are many positive outcomes related to physical, mental, and emotional health (Mazzoli et al., 2021; Popeska et al., 2018; Raney et al., 2017). Physical activity has a positive influence on cognitive performance and psychological health (Poitras et al., 2016). The current study measured physical activity through aerobic and anaerobic fitness, including light to moderate to vigorous activity and steps walked (Buchele Harris et al., 2018; Alhassan et al., 2016). Several studies have shown that increased sedentary levels in academic settings create negative health-related issues, disruptive behaviors, and disengagement in learning (Juonola et al., 2013; Väistö et al., 2014; Perera et al., 2015). Previous studies have found that disengagement in learning, specifically in older students, may be due to social factors such as peer pressure and self-consciousness or embarrassment of one's ability (Webster et al., 2017). Research has found that as students progress from elementary to high school, physical activity levels decrease (Haapala et al., 2014). Researchers have found personal and economic preferences, sociocultural pressures, and environmental opportunities are the three areas of the school day that could affect individual children's physical activity levels (Eskola et al., 2018). Prejudicial stereotypes such as weight bias can leave older students self-conscious about their body, movements, and others' perceptions of their abilities leading them to show little interest in participating (Finn et al., 2020). Studies show that when students are engaged in moderate to vigorous physical activity, they experience a decreased amount of physical fatigue, allowing them to concentrate on concepts and tasks (Mok et al., 2020; Glapa et al., 2018; Kuan et al., 2019). Teachers should also consider the fitness levels of their students, as some have lower fitness levels that would require adjusting the frequency and intensity of brain breaks. For example, students with disabilities often experience physical fatigue because this population relies on school-based physical activity more than their typically developing peers (Mazzoli et. al, 2021). Research suggests one mechanism used by schools to address the physical activity guidelines is the use of physical education (Bulca et al., 2022). Some of the studies included in the current investigation used physical education as a brain break or as a control condition (Chancey, 2019; Janssen et al., 2014). One study found that incorporating an academic curriculum into a student's physical education period produced desired outcomes with a greater effect than integrating physical activity into the classroom setting (Alvarez-Bjueno et al., 2017). Studies using active lessons where the learning environment was connected to games and activities designed to reinforce learning outcomes were also included as a part of the analysis (Bartholomew et al., 2018; DiBitetto, 2016; Donnelly et al., 2017; Snyder et al., 2017; Vazou et al., 2017; Cole et al., 2008; Mullender et al., 2015). Few studies investigated how brain breaks influenced outcomes for students with disabilities in secondary settings. While the results from these studies are inconclusive, the evidence across several different content areas suggests and recommends that children and adolescents benefit by incorporating physical activity through either active lessons or school-based physical education (Bulca et al., 2022; Carlson et al., 2015; Mazzoli et. al, 2021; Barr-Anderson et al., 2011).).

RECOMMENDATIONS

The Brain Break interventions researched in this study have shown to produce variable results that range from small to strong overall effects. Future research is encouraged to replicate studies that will permit refinement and implementation of Brain Break intervention for students of all ages and ability levels. Future research should consider the following information when designing future studies to assess the impact of Brain Breaks. The number of outcomes reported was limited, and there was a high degree of variability between studies. The effect of brain breaks on gender is limited, specifically on females, as most studies have been conducted with male or mixed gendered samples (Ma et al., 2014). Future research would benefit from studies with larger sample sizes. Overall, more specific information is needed on how specific brain breaks influence cognitive, psychomotor, and affective outcomes in students with and without disabilities

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