THE EFFECT OF BRAIN BREAKS ON STUDENT ACADEMIC PERFORMANCE AND BEHAVIORS IN THE K-12 SCHOOL SETTING; A META-ANALYSIS

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Abstract

THE EFFECT OF BRAIN BREAKS ON STUDENT ACADEMIC PERFORMANCE AND BEHAVIORS IN THE K-12 SCHOOL SETTING; A META-ANALYSIS

Jesse Singh

The purpose of this meta-analysis is to examine the effect of brain breaks on academic performance and in-class behaviors in the K-12 educational setting. Also, to conduct subgroup (moderator) analyzes to determine if Brain Breaks were more effective for specific (school and student) population characteristics. Standard meta-analytical procedures were used to determine inclusion criteria, article searches in electronic databases, coding procedures, and statistical methods to synthesize data. Moderator and outcome variables were assessed using coding procedures to understand if Brain Breaks were effective or not. The brain break interventions researched in this study have shown to produce variable results in subgroup analyses that range from ineffective to strong overall effects

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Introduction

Within the school setting students can spend much of their day sitting and in sedentary state (Cardon., et al. 2004, Ucci et al., 2015, Ee et al., 2018). Duan et al. (2015) observed half of the students spent excessive time engaging in sedentary behaviors, such as academic related-activities and screen-based activities, even though they participated in an hour of moderate to vigorous exercise. 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). Disruptive or off task behaviors can include class interruptions, inattentiveness, and eye gazing (Godwin et al., 2013). Other than physical education class, students have multiple opportunities to be active such as during break or recess, walking to and from school, and if they participate in sport (Watson et al., 2017). Despite these opportunities to engage in physical activity, researchers have consistently reported sedentary levels outweigh physical activity levels for this population (Parrish et al., 2018; Khan et al., 2019). A way to implement movement, increase physical activity levels, and reset the classroom is by doing a brain break (Rizal et al., 2019).

Educators are continually seeking ways to implement effective classroom management techniques that will decrease disruptive behaviors and increase/improve academic outcomes (Oliver, Wehby, & Reschly 2011; Gage, et al., 2018). The school environment is where students learn (or not) to manage their physical, emotional, and academic behaviors due to numerous positive and negative social interactions that are present in school contexts (Hughes et al., 2012). Teachers and schools provide structure and accountability that are designed to reinforce desired academic outcomes, however, not all schools provide a formal structured environment (Wang & Holcombe, 2010). During the informal and unstructured times students use their behavioral self-regulation skills to navigate those positive and negative situations and interactions (Howse et al., 2003). Research has found that moderate to vigorous bouts of physical activity for varying periods of time can be an effective method to produce positive results for numerous academic outcomes (Caldwell & Ratliffe 2014; Mok et al., 2015). However, research has found that physical activity levels decrease as children age and when combined with teaching methods that do not use physical activity as a strategy to improve academic outcomes opportunities are missed (Haapala et al., 2014). Considering these findings, teachers might benefit from using new approaches to student success by providing the most academic and aerobic movement breaks throughout the school day (Fedewa, 2018).

Physical activity has been shown to positively influence cognitive performance and psychological health (Poitras et al., 2016). 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, 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 while they are in a classroom setting. Research has linked being sedentary for longer periods in classrooms to eye strains, spinal pressure, and decreased deep breathing which negatively influences student attention and concentration (Morton, 2016). When students are given the opportunity to move during a lesson, research has shown that they experience a decreased amount of physical fatigue and are better able to concentrate with efficiency on concepts and tasks (Mok et al., 2015; Uzunos et al., 2017; Glapa et al., 2018; Popeska 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. Following a physical brain break, blood flow increases brain activity in students, allowing the brain to remain alert for learning (Erlauer, 2003).

Literature Review

Brain Break Definition

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, 2014). Brain breaks involve physical activity as means to activate the information processing areas of the brain by changing up the routine of incoming information to the prefrontal cortex where problem-solving and emotional regulation occurs (Mazzoli et al., 2021). While there are numerous methods and definitions that have been used to specify brain breaks, the definition that focuses 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, 2020). Research that has been conducted on using these types of physiological methods have 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; Mullender et al, 2015; Voss et al, 2011). When the body is engaged in some form of movement the brain is able to refocus and stimulate neural pathways in the prefrontal cortex where learning is linked to performance (Desautels, 2016).

Types of Brain Break

Educators have identified three categories that brain breaks can be divided into activities that are attributed to breathing or relaxation, involve vigorous physical activity between portions of a lesson, and those which focus on mental activity (Weslake and Christian, 2015). A combination of all of these can be used to maximize the time of a brain break while integrated into the lesson such as the example of standing and pretending to ride a surfboard while you are skimming the waves (Gay, 2013). Mok (2020) uses iPads and YouTube so students can find their own exercise video as an individualized movement break. Elementary school students can easily participate in relaxation and stretching movements (Bobe, 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 considered “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 feeling their belly grow with every inhale and feeling the warm air of every exhale. Another form of breathing that 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 that 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.

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 (Vander Waal 2020, Jansenn et al., 2014). While students are given an opportunity to participate in unstructured activity such as recess, the imbalance of activity and sedentary behavior prevents students from maximizing cognition. Based on study findings, teachers can improve several student outcomes through the use of brain breaks (Janssen et al. 2014; Howie et al., 2014; Carolson et al., 2015, Mead et al., 2016). Specific time periods listed in the literature include mornings immediately after classes begin, after transition periods such as from lunch back to class, and near the end of the school day (Cline et al., 202: Janssen et al. 2014; Howie et al., 2014; Carolson et al., 2015, Mead et al., 2016). 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 time of day, transition periods during school day, cognitive effort of subject matter, and shifting changing student attitudes (Cline et al., 202: Janssen et al. 2014; Howie et al., 2014; Carolson et al., 2015, Mead et al., 2016).

Duration

Teachers need to manage time spent on academic learning and implementation of a brain break as a shift and balance between sedentary and active behaviors is critical. Research that has been done on the duration of activity indicates specific time periods are more beneficial (Daly-Smith, 2017, Hajar et al., 2019, Jensen 2005). Studies have found that when brain breaks are implemented for 10 minutes or more, student cognitive performance improves (Jansenn et al, 2014, Daly-Smith 2017, Howie et al., 2014). Additional research on shorter time periods has found that the application of brain breaks that are from one minute to five minutes have the potential to show improvements in academic retention and attention (Daly-Smith, 2017, Hajar et al., 2019, Jensen 2005). Research recommends that teachers using brain breaks should consider the type of activity appropriate to the duration, connecting the type break break to the content being taught (efficient use of time), the classroom space where the brain break will be implemented, and to ensure that activity matches student skill and fitness levels. Brain Breaks are an excellent way 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 learning expectations. The learning environment is dynamic and changing and research has found that sometimes teachers are not always aware of specific factors such as the balance between sedentary cognitive activities and movement that stimulates the brain (Perrey, 2013). When teachers are able to track and identify student cues related to 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, 2017). One specific outcome important to student performance and learning is being able to attend, focus, and respond to the immediate task. Attention plays a vital role in students' success as they are able to interpret information provided in a timely manner to successfully complete tasks being assigned (Fedewa, 2018). Research has found that when students are more attentive during a lesson produce positive outcomes such as having greater retention of content, content recall can be accessed faster to respond favorably to the task, and transition between activities is more efficient (Reilly, Buskist & Gross 2012).

Attention and Focus

Research shows that students who participate in movement breaks during a lesson attribute to less disruptive behavior and showed vast improvements in attention (Camahalan & Ipock 2015, James-Burdumy et al. 2013). Given the inconsistent findings of the literature, there is not enough evidence to support the claim that activity breaks always have a positive effect on cognitive functioning in students (Calvert, 2019; Daly-Smith, 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, 2021). Studies have identified positive associations between brain breaks and attention to task, academic achievement, and academic behavior as teachers reported increased focus and engagement and decreases in behavioral problems after introducing brain breaks (Baker, 2017). Recommendations from these articles convey play/brain breaks as positive attention getters for students' academic performance. The physiological mechanism underlying this effect is that brain breaks help students be active in and outside of the classroom and 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-Burdumy et al. 2013, Chang and Coward 2015). What is clear from the literature is that when students are sedentary for an extensive amount of time they are more likely to display more off task behavior that is counterproductive to desired outcomes such as learning and achievement (Barriga, 2002; Finn, 1995).

Disruptive/Maladaptive Behavior

There are various ways to define disruptive/maladaptive behaviors. Research defines maladaptive behaviors as any kind of aggression towards one self or others that can affect learning (McDaniel and Flower 2015, Purwati and Japar 2017, Cholewa, Smith-Adcock, and Amatea 2010). There are various forms of disruptive behavior that can take part in the classroom. Some of these disruptive behaviors include: showing aggression towards oneself or others, screaming, disobeying, breaking class objects, getting attention, or raging (Schroder & Gorden, 2002). The educational literature has consistently shown that classroom management strategies involving activity can be used as preventative measures to both inconsequential and severe disruptive behaviors as mentioned above (Maggin et al., 2011). Classroom management strategies that facilitate effective brain breaks include specific components of universal design for learning (modeling, visuals, pre-teaching, etc.), and repetitive activities to ensure efficient and effective implementation, and finally a variety of activities that use different types of activity to ensure motivation (Oliver, Wehby, and Reschly 2011). 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; Maggin et al., 2011). There are distinct parallels between classroom management strategies and brain breaks as they improve cognitive fatigue, losses in attention/focus, disruptive behavior, decrease boredom, increase student engagement, and increase time on task (Oliver, Wehby, and Reschly 2011; Cline et al., 2021; Maggin et al., 2011).

Implementation Strategies for Brain Breaks

Implementing brain breaks in the educational setting has to come with a strategic approach and different ages and developmental levels respond differently. According to the literature, elementary teachers should use technology (Brain Break video) as results suggest student improvements in physical activity attitudes and cognitive performance (Popeska et al., 2018; Zhou et al., 2021, Cline et al., 2021). Fewer research studies have been conducted on secondary students (High School) and findings showed no improvements in academic performance after the implementation of a brain break video (Maddox 2019; Donner 2013). Another consideration should be whether students are typically developing or have been diagnosed with a mild to moderate disability such as ADHD or autism (Schilling and Schwartz 2004; Bagatell et al., 2010). 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 with the use of stability balls (Mead et al., 2016). There are a number of factors that need to be considered when implementing break breaks, most notably teachers should consider experimenting with different types of brain breaks according to research parameters.

Statement of the Problem

Research that has been conducted on Brain Breaks using moderate to vigorous physical activity has found positive benefits across a number of 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 success 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) analyzes to determine if Brain Breaks were more effective for specific (school and student) population characteristics.

Methods

Search Strategy

Search strategies were developed by using keywords that were determined by the author (Moher, Liberati, Tetzlaff, Altman, & Prisma Group, 2009). The main keywords that were 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 inputted into several academic databases that include: *SPORTDiscus, ERIC, PsychINFO, PubMed/Medline, Child Development and Adolescent Studies, and PsychARTICLES.* ProQuest was used to determine if thesis and dissertations were unpublished or had publication bias. A three-stage screening process was implemented during this analysis. In the first stage, two authors conducted initial searches utilizing the main keywords and diving academic databases. If the article appeared relevant to the context of this study, the authors saved the citation of the article to a citation program (EndNote X7) and after completing initial searches all duplicates were removed. In the second stage, the articles that were saved in the article citation database were independently screened by two authors. If the abstract did not provide sufficient information, 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 during review of full texts the lead author was contacted requesting missing information.

Inclusion and Exclusion Criteria

Inclusion criteria was implemented to determine if articles were saved by the authors 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 three to twenty-two (3-22) years of age; (c) the study included movement, (d) the study had a quantifiable measure outcome; (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 activity taking place in an educational setting during school hours. Physical Activity (PA) settings was defined as activity taking place outside of a school setting. Classroom settings were defined as in room during academic curricula. Adapted physical activity was defined as an educational setting that used accommodations and modifications during activity.

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 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).

Outliers

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 $>\pm$ 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 results remaining unchanged (marginal influence on the effect size and associated p-value) and within 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) software was utilized to calculate effect size statistics (Borenstein, Hedges, Higgins, & Rothstein, 2005). 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 not available, then we used F-values, t-values, and/or P-values from each study (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 both sampling error and between study variance to estimate the effect size. Also, when several outcomes were extracted, the study was the unit of analysis and a procedure will be used that averages 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 Q_{Total} (Q_T) value based on χ-square (χ^2) distribution reports if studies share the same effect size, tau-square (τ^2) value provides the variance of true study effects, and Isquare (I^2) value indicates provides the proportion of the variance that between observed and true effects. Significant Q_T statistics are then categorized into $Q_{Between}$ (Q_B) and Q_{Within} (Q_W) values and significant Q_B values ($p < 0.05$) require statistical techniques to determine subgroup differences.

Results

Outliers and Publication Bias

Six studies were identified as outliers (Ahamed et al. 2007, z = -2.59; Mavildi 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; and Huddleston 2017, z = 4.50), therefore, a one study removed process (CMA analysis) 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 been reduced (g = $\pm$ 0.04) with results and interpretation remaining similar. Considering these criteria all outliers were retained in the 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 a symmetrical distribution on both sides of the funnel plot. Figure 2 provides the funnel plot and Trim and Fill procedure which confirmed the symmetry by adding no studies to the left of the funnel plot. Due to no addition of studies, the overall study statistics did not change (g = 0.35, *95% CI* = 0.21, 0.49, P < 0.001). Begg and Mazumdar rank order correlation was significant (P < 0.001) which means there was a possibility of a small study effect. However, Egger's regression intercept was not significant (P = 0.68) which contradicts results from Begg and Mazumdar's findings. Given the combination of these analyses there is a possibility that a "small study effect" was present and that the addition of potential studies may decrease overall effect size estimates (Sterne et al., 2011).

Table 1

Activity Break Study Characteristics. Methodological characteristics are design, time, type, frequency and setting. Sample characteristics are level, gender, country, and N. Study characteristics are measurement, fund, and status.

Study	Design	Time	Type	Frequency	Setting	Level	Gender	Country	N	Measurement	Fund	Status
Adaland et al., 2018	E	2-5	O	3	C	ET	B	Norway	1202	C	U	P
Ahamed et al. 2007	E	5	M	3	C	ET	B	Canada	288	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
Balasekaran et al. 2021	E	2-5	M	3	C	ET	B	Singapore	113	S	U	P
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
Cole et al. 2008	E	5	AL	NR	C	ET	B	US	128	C	U	P
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. 2018	E	5	M	NR	C	ET	B	Switzerland	216	O	U	P
Egger et al. 2019	E	5	M	3	C	ET	B	Switzerland	142	O	U	P
Fedewa et al. 2015a	E	5	O	NR	C	ET	B	US	67	C	U	P

Study	Design	Time	Type	Frequency	Setting	Level	Gender	Country	N	Measurement	Fund	Status
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
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 2017	E	5	M	3	C	ET	B	US	137	O	U	P
Goh et al., 2016	E	5	M	3	C	ET	B	US	210	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
Hunter et al. 2014	E	5	M	3	C	ET	B	Australia	107	C	U	P
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
Ma et al. 2014	E	2-5	M	3	C	ET	B	Canada	44	O	U	P
Macdonald et al. 2021	E	5	O	3	C	ET	B	Australia	64	O	U	P

Study	Design	Time	Type	Frequency	Setting	Level	Gender	Country	N	Measurement	Fund	Status
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
Mawar 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
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
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
Osdol et al. 1974	E	5	O	3	C	ED	B	Australia	26	O	U	P
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
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
Schmidt et al. 2016	E	5	M	2	C	ET	B	Switzerland	98	O	U	P

Study	Design	Time	Type	Frequency	Setting	Level	Gender	Country	N	Measurement	Fund	Status
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
Vazou et al. 2017	E	5	AL	3	C	ET	B	US	124	C	U	P
Watson-Grace et al. 2020	E	5	O	2	O	MT	B	US	28	C	U	P
Wilson et al., 2016	E	5	M	2-3	O	ET	M	Australia	58	O	U	P
Zhou et al., 2016	E	2-5	M	3	C	ET	B	China	780	S	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; Funded and U = Unfunded. Status = Publication Status; P = Published and U = Unpublished

Table 2

Activity Break Subgroup Analysis. Effect size statistics are k, g, SE, s^2, and CI; Null test Z and P; and Heterogeneity Statistics PI, Q, τ^2, and I^2.

Variable	*k*	*g*	*SE*	s^2	CI	Z	P	PI	*Q*	τ^2	I^2
Methodological											
Time							0.00[B]		18.37[B]		
<2 Minutes	1	2.62	0.57	0.33	1.50, 3.74	4.58	0.00		0.00	0.00	0.00
>5 Minutes	37	0.27	0.09	0.01	0.10, 0.44	3.12	0.00	-0.70, 1.24	548.71	0.22	93.44
2-5 Minutes	12	0.49	0.15	0.02	0.20, 0.78	3.31	0.00	-0.75, 1.73	211.54	0.29	94.80
Multiple	2	0.04	0.07	0.12	-0.56, 0.81	0.35	0.72		4.03	0.05	76.76
NR	2	0.10	0.21	0.17	-0.75, 0.86	0.13	0.89		0.40	0.00	0.00
Type							0..97[B]		0.23[B]		
Aerobic	3	0.33	0.31	0.10	-0.28, 0.94	1.07	0.28		41.25	0.31	95.15
Active Lessons	7	0.45	0.22	0.05	0.02, 0.88	2.04	0.04	-0.31, 1.21	18.84	0.04	68.15
Mixed	37	0.35	0.10	0.01	0.16, 0.51	3.73	0.00	-0.74, 1.44	655.32	0.28	94.51
Other	7	0.34	0.22	0.05	-0.08, 0.76	571	0.12	-1.34, 2.02	62.88	0.38	90.46
Frequency							0.51[B]		2.32[B]		

1 Day/Week	1	0.63	0.54	0.29	-0.43, 1.68	1.16	0.25		0.00	0.00	0.00
2-3 Day/Week	10	0.48	0.17	0.03	0.14, 0,81	2.79	0.02	-1.01, 1.97	98.65	0.39	90.88
>3 Day/Week	33	0.36	0.09	0.01	0.18, 0.55	3.86	0.00	-0.72, 1.44	617.01	0.27	94.81
NR	10	0.14	0.17	0.03	-0.20, 0.48	0.82	0.41	-0.78, 1.06	97.04	0.13	90.73
Setting							0.26^{B}		2.68^{B}		
Classroom	50	0.38	0.07	0.01	023, 0.52	5.14	0.00	-0.57, 1.33	761.43	0.22	93.57
Outside	2	0.15	0.37	0.14	-0.58, 0,88	0.41	0.69		1.82	0.05	44.95
Physical Education	2	-0.19	0.36	0.13	-0.88, 0.51	-0.52	0.60		7.57	0.22	86.78
Sample											
Gender							0.44^{B}		0.61^{B}		
Female & Male	53	0.36	0.07	0.01	0.21, 0.50	4.83	0.00	-0.63, 1.35	867.03	0.24	0.08
Level							0.50^{B}		1.40^{B}		
Combined	7	0.49	0.20	0.04	0.10, 0.88	2.49	0.01	-1.16, 2.14	137.04	0.37	95.62
Elementary School	41	0.35	0.08	0.01	0.19, 0.51	4.21	0.00	-0.63, 1.33	687.54	0.23	94.18
Middle School	6	0.14	0.23	0.05	-0.31, 0.58	0.61	0.54	-0.60, 0.88	7.18	0.02	30.39

Composition							0.19[B]		3.31[B]		
Combined	4	0.23	0.29	0.08	-0.33, 0.80	0.81	0.42	-0.34, 0.80	2.03	0.00	0.00
Disabled	1	1.51	0.65	0.43	0.22, 2.79	2.30	0.02		0.00	0.00	0.00
Typically Developing	49	0.34	0.08	0.01	0.19, 0.49	4.50	0.00	-0.66, 1.34	860.64	0.24	94.42
Country							0.95[B]		6.54[B]		
Australia	5	0.33	0.28	0.08	-0.22, 0.87	1.17	0.24	-1.15, 1.81	14.10	0.14	71.63
Canada	3	-0.01	0.35	0.12	-0.69, .67	-.03	0.97		48.03	0.89	95.84
China	1	0.16	0.57	0.32	-0.95, 1.27	0.28	0.78		0.00	0.00	0.00
Germany	1	-0.03	0.62	0.38	-1.24, 1.18	-0.05	0.96		0.00	0.00	0.00
Italy	1	0.25	0.58	0.34	-0.89, 1.39	0.43	0.67		0.00	0.00	0.00
Macedonia	1	0.52	0.58	0.33	-0.61, 1.65	0.91	0.36		0.00	0.00	0.00
Malaysia	1	-0.02	0.57	0.33	-1.14, 1.10	-0.03	0.97		0.00	0.00	0.00
Netherlands	3	0.47	0.34	0.12	-0.20, 1.14	1.37	0.17		212.16	1.95	99.06

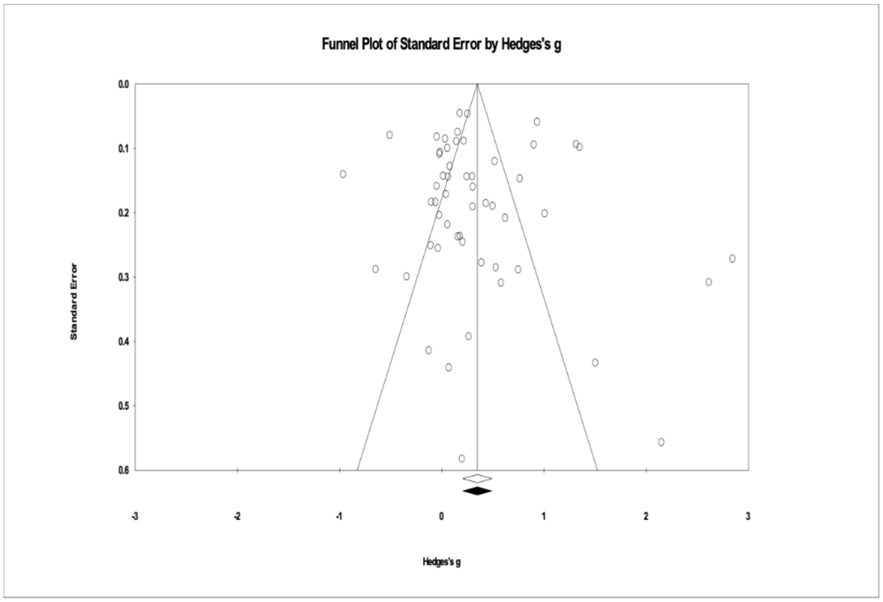
Norway	1	0.94	0.57	0.32	-0.17, 2.05	1.66	0.01		0.00	0.00	0.00
Poland	1	0.77	0.58	0.34	-0.37, 1.91	1.32	0.19		0.00	0.00	0.00
Singapore	1	1.01	0.60	0.36	-0.16, 2.18	1.69	0.09		0.00	0.00	0.00
Spain	1	0.63	0.60	0.36	-0.55, 1.80	1.04	0.30		0.00	0.00	0.00
Switzerland	3	0.13	0.33	0.11	-0.53, 0.78	0.38	0.71		2.76	0.01	27.44
UK	3	0.09	0.33	0.11	-0.56, 0,74	.27	0.79		4.33	0.02	53.76
US	28	0.40	0.12	0.01	0.17, 0.63	3.46	0.00	-0.66, 1.46	379.89	0.25	92.89
Study											
Measurement							0.92[B]		0.92[B]		
Objective	34	0.33	0.09	0.01	0.16, 0.51	3.51	0.00	-0.66, 1.32	556.88	0.23	95.09
Subjective	7	0.41	0.21	0.04	0.01, 0.82	2.03	0.04	-0.49, 1.31	38.42	0.08	94.07
Combined	13	0.37	0.15	0.02	0.07, 0.66	2.39	0.02	-1.28, 2.02	38.42	0.54	84.38
Funding							0.80[B]		0.07[B]		

Funded	1	0.21	0.55	0.30	-0.87, 1.29	0.38	0.71		0.00	0.00	0.00
Unfunded	53	0.35	0.07	0.01	0.21, 0.49	4.76	0.00	-0.64, 1.34	870.67	0.24	94.03
Status							0.93[B]		0.01[B]		
Published	45	0.35	0.08	0.01	0.19, 0.50	4.31	0.00	-0.63, 1.33	770.66	0.23	94.29
Unpublished	9	0.36	0.18	0.03	0.00, 0.72	1.97	0.05	-1.32, 2.04	100.02	0.47	92.00

Note. *k* = number of studies, Hedges *g* = Effect Size, s2 = variance, SE = Standard Error, *95% CI* = Confidence Interval (Lower Limit, Upper Limit), *Z* = Significance Test; *PI* = Prediction Interval (lower limit, upper limit), τ^2 = Between Study Variance,. B = *Q*-value between groups used to evaluate significance with corresponding *P*-value. * $p < 0.05$. Some Prediction Intervals are incomplete due to inadequate sample size.

Figure 1

Funnel Plot of Standard Error



Subgroup Analyses

Each study meeting inclusion criteria were coded according to three categories that included methodological characteristics (Time, Type, Frequency, and Setting), sample characteristics (Gender, Level, Composition, and Country), and study characteristics (Measures, Funding, and Status) and are presented in Table 1 with Table 3 providing the statistical information.

Several trends were apparent in the methodological data that included small effects for Brain Breaks across multiple outcomes for Time (k = 37 - 12, g = 0.27 – 0.49), Type (k = 37, g = 0.35), and Frequency (k = 10 - 33, g = 0.48 – .36). Sample characteristics also presented trends with small effects including combined samples for Level (k = 41, g = 0.35) and Composition (k = 49, g = 0.34). Finally, the trends for Study characteristics included a combination of both objective and subjective Measurements ($k = 13$, $g = 0.37$). As noted with the outcomes, there were large prediction intervals between each of the subgroup categories that would suggest varying degrees of effectiveness (not effective to highly effective) for brain breaks across a variety of outcomes.

Discussion

The purpose of this study was to assess the effect of Brain breaks in school-based educational settings to improve skill-related outcomes and to conduct subgroup (moderator) analyzes to determine if Brain Breaks were more effective for specific (school and student) population characteristics. 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 related to students' achievement across several subject matter curricular areas. 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 teacher perception due to the school day time constraints (McMullen et al., 2014). 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). Teachers who have demonstrated positive outcomes using brain breaks have various opportunities throughout the day, 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-Bueno 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). 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).

Data characteristics in this meta-analysis showed varying tendencies. Moderate and long term activity breaks are more effective than other time periods. Brain breaks that included various types of movements were more functional in students and their academic outcomes. The recurrence of brain breaks is a trend that needs to be looked at. At the elementary level, brain breaks were shown to be effective compared to middle school and high school students. Typically developing students and brain breaks were shown to be competent on outcomes. There needs to be more research done on students who have disabilities.

Methodological Characteristics

Methodological characteristics examined brain break differences through a variety of subgroup analyses focusing on how studies were conducted including different time periods, frequency, and type of brain break activity. Physiological research on brain break suggests that a variety of activities will stimulate a number of outcomes for students such as executive function, appropriate classroom behavior, and academic performance (Hajar et al., 2019; Hidrus et al., 2020). Studies included in the analysis ranged from less than two minutes, two to five minutes, and greater than five minutes with the majority of studies employing longer time period brain breaks. Research suggests that brain break time periods of ten minutes that utilize exercise are more likely to improve a variety of desired student outcomes (Howie et al., 2014; Murtagh et al., 2013). The only two brain break time periods (2-5 minutes, and > 5 minutes) providing enough information suggest that brain breaks range from ineffective to highly effective. These findings are helpful in providing guidance related to implementing brain breaks and knowing the type of exercise that will improve student outcomes.

The type of brain breaks used by classroom teachers becomes an important consideration as different types of exercise can affect varying parts of the brain (Hung et al., 2018). Teachers should employ activities that align with stimulating the correct area of the brain to maximize desired student outcomes. The categories of brain breaks included aerobic exercise, only active lessons, a mix of exercises, and other types of exercise (stretching or breathing). The majority of studies used a variety of brain break types and results were similar across all categories suggesting overall small effects with a high degree of variability. Research that has studied brain activity has found that there are benefits to aerobic activity to increase cognitive functioning (Barha et al., 2017) as well as the use of mindfulness breathing techniques to increase in academic performance (Cloutier 2011). Similarly, resistance training significantly enhanced cognitive performance compared to aerobic exercise groups and non-exercise groups (Harveson et al., 2019). What is apparent from the current findings is that all types of exercise show improvements across student outcomes, however, more information is needed about the type of brain break connected to biofeedback indicators and stimulated area of the brain (Fedewa et al., 2018; Calvert et al., 2019; Daly-Smith et al., 2018). Our findings are inconclusive as the only category that provided enough evidence for study was a mix of brain break exercises, however, these results have a large variability of effectiveness that need further investigation.

Knowing how often and where to implement movement brain breaks into the classroom is crucial in the learning environment (Jovanova-Mitkovska & Popeska, 2019). Physical activity is a requirement every day and if children are sedentary their mental acuity and sharpness is stale (Barriga, 2002; Finn, 1995). Research suggests that brain breaks are a great way to execute movement in any setting and provide a mental reset (Turner, 2017). Studies in this current investigation included frequencies ranging from one day, two to three days, or more than three days per week. Although there were not enough studies ($k > 10$) that reported on different frequencies, brain breaks that were conducted more than three times a week (k=33) and two to three times a week (k=10) were most apparent. Frequently providing students opportunities in any setting to be active allows them to increase academic performance and attention (Singh et al., 2019). Several professional organizations recommend that physical education may have the opportunity to increase activity and improve test scores (Watson et al., 2017; Rasberry et al., 2011). However, break breaks and school based physical education should be used in combination to improve students cognitive functioning (Alvarez-Bueno et al., 2017; Mazzoli et. al, 2021; Barr-Anderson et al., 2011; Bulca et al., 2022; Carlson et al., 2015). In this current investigation, brain breaks were most practiced in the classroom setting (k=50). Nonetheless, future studies on brain breaks need to better connect with both physical education and classroom activity.

Sample Characteristics

Three specific sample characteristics deserve additional attention and included gender, student age level, and developmental level. A moderating variable like gender, can have potential to affect student educational outcomes and there was clearly a lack of disaggregated data for male and female samples. Data suggest that females have better academic outcomes, however, females with and without disabilities have lower physical activity levels which may be connected to lower quality of life outcomes (Dovore et al., 2009; Longmuir et al., 1994; Sundahl et al 2016). The paradox between activity and academic outcomes is further exacerbated by these gender differences in the different literatures as there is clearly an interaction between activity and academic outcomes in physiological and education studies (Farooq et al., 2020; Norris et al., 2015; Erwin et al., 2012; Keays & Allison 1995). Being able to understand the nuances between gender, activity, and academic outcomes becomes an important focus as gender specific interventions may be needed to improve student educational outcomes using activity breaks (Trost et al., 1996; Yu et al., 2006; Vasickova et al., 2013).

Physical activity decreases as students grow older which may influence their cognitive functioning as well as number of outcomes in school settings (Nader et al., 2008; Haapala et al., 2014). At a younger age, students have greater energy expenditure levels and are more likely to participate in physical activity. Brain breaks for younger students may influence and help their cognitive development and executive functioning (Bulca et al., 2022). When comparing students at different age and developmental levels, students at the secondary level have better self-regulation skills and are provided with more autonomy in physical activity engagement. What was observable in the current investigation, a majority of studies were done on students at the elementary level (k=41). Some potential reasons that studies were more likely to engage elementary students is that brain breaks may allow adolescents to become self-aware and work on their executive functioning (Bulca et al., 2022). The main issue is that brain breaks are needed throughout the progression of educational experience and finding ways to implement brain breaks that stimulate learning and improve student outcomes across the age groups and developmental levels is needed (Alvarez-Bueno et al., 2017; Perera et al., 2015; Webster et al., 2017, Howie et al., 2014).

Participating in physical activity at an early age can lead to a better quality of life (Gu, Chang, & Solmon 2016; Shoup et al., 2008; Maher, Toosey, & Ferguson 2016: Toscano, Carvalho, & Ferreira 2018). In this analysis, the majority of studies involved typically developing students (k = 49), whereas only one study used students who have disabilities. More information will benefit Brain Break literature to see how physical activity in the classroom affects disabled populations' education outcomes and behaviors. Adding movement into the school day can positively influence academic performance in students (Rasberry et al., 2011; Trudeau & Shephard 2008; Hills, Degens, & Luban 2015). Studies that met the inclusion criteria for this analysis were dominated by the United States (k = 28) with the next highest being Australia (k = 5). The current investigation was not able to provide a cultural perspective on how brain breaks influence educational outcomes and maladaptive behaviors according to culture or developmental levels. Additional information will benefit the students with disabilities literature on how cultural differences (or not) might target specific brain breaks to improve academic performance. The lack of country specific data also emphasizes the lack of power associated with study sample sizes which ranged from six to 90 subjects. Both publication bias statistics as well as prediction interval data reveal small study effects connected to larger study variability and inconsistent results. These findings highlight the need for larger studies from diverse populations.

Study Characteristics

Study characteristics included types of measurement which have potential interactions related to the other subgroup analyses. The three that were included in this analysis were: Objective, Subjective, and Combined. Objective measurements included tests, homework samples, etc. Subjective measurements included Likert scales, self-reports, questionnaires etc. Some studies included both types of measurements. The majority of studies had objective types of measurement. Objective measures give us reliable and factual results on academic performance. Although objective measures are more valid, subjective measures give us responses to actual experiences. A combination of both types of measure can give a complete result of the students' school experience.

Funding and publication status were also viewed which could have a possible interaction in the analysis. The majority of studies included were published and were unfunded. Grant funding provides resources that allow larger samples, more rigorous studies, and higher quality design. In this search process, it is apparent most studies were published in journals. Although publications go through a rigorous process, limitations still exist in predicting true estimates of the effects of brain breaks and academic performance, attention/focus, and physical activity. The publication bias literature suggests there are a number of procedures that can be used to mitigate these biases (Rothstein, Sutton, & Borenstein, 2005).

Recommendations

The Brain Break interventions researched in this study have shown to produce variable results in subgroup analyses that range from ineffective 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. Brain Break research needs to expand to different parts of the world. The literature can benefit from the cultural perspectives of Brain Breaks and how effectiveness is compared between countries. Also, expanding research to students who have disabilities. Future research can look at the results of implementing a Brain Break with students who are on Behavior Intervention Plans (BIP). Overall, more specific information is needed on how specific types of brain breaks influence cognitive, psychomotor, and affective outcomes in students with and without disabilities.

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