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A SYSTEMATIC REVIEW ON THE EFFECTIVENESS OF BRAIN-BREAKS® VIDEO PROGRAMMING ON ACADEMIC PERFORMANCE AND PHYSICAL ACTIVITY OF SCHOOL CHILDREN

SYSTEMATIC REVIEW

ABSTRACT

Purpose: This study aimed to complete a systematic review of the effect of the Brain Breaks® video program on academic performance and health-related outcomes among schoolchildren.

Methods: A literature search was performed using Scopus, PubMed, ResearchGate, ScienceDirect, and Google Scholar databases to identify published manuscripts from December 2017 to December 2023. Dissertations, theses, monographs, and commentaries were excluded from this review.

Results: A total of 15 studies were included in the review. Most studies applied quasi-experimental design and were conducted in Asia and Europe with children. Nine of these studies found that Brain Breaks® improved students' attitudes toward physical activity (PA), and two found that it improved their PA levels. The other studies found that Brain Breaks® improved students' academic performance, perceived pros and cons of PA, transtheoretical model (TTM) constructs, motivation to participate in PA, cognitive function, muscle strength, muscular endurance, and flexibility, as well as the fitness knowledge test and the Fitnessgram test battery results.

Conclusion: It is thought that the Brain Breaks® web-based online video program has the potential to improve the academic performance and health-related physical fitness of school children

Keywords: Attitude, Brain-Breaks, Cognitive Functions, Childhood, Physical Activity

BRAIN-BREAKS® VİDEO PROGRAMININ OKUL ÇOCUKLARININ AKADEMİK PERFORMANSLARINA VE FİZİKSEL AKTİVİTELERİNE ETKİSİ ÜZERİNE SİSTEMATİK BİR İNCELEME

SİSTEMATİK DERLEME

ÖZ

Amaç: Bu çalışmanın amacı, BrainBreaks® video programının öğrencilerin akademik performansları ve sağlıkla ilgili sonuçları üzerindeki etkisinin sistematik incelemesini yapmaktır.

Yöntem: Aralık 2017'den Aralık 2023'e kadar yayınlanan makaleleri belirlemek için Scopus, PubMed, ResearchGate, ScienceDirect ve Google Scholar veritabanları kullanılarak literatür taraması yapılmış olup tezler, monografiler ve yorumlar bu incelemenin dışında bırakılmıştır.

Sonuçlar: İncelemeye toplam 15 çalışma dahil edilmiştir. Çalışmaların çoğunun yarı deneysel olduğu, Asya ve Avrupa'daki çocuklar üzerinde yürütüldüğü saptanmıştır. Bu çalışmaların dokuzu Brain Breaks®'in çocukların fiziksel aktiviteye karşı tutumlarını, ikisi ise fiziksel aktivite düzeylerini geliştirdiğini göstermiştir. Ayrıca diğer çalışmalar bu programın çocukların akademik performanısnı, fiziksel aktivitenin artı ve eksilerine ilişkin algılarını, transteorik model (TTM) bileşenlerini (değişim süreçleri, karar vermede denge ve öz yeterlik), fiziksel aktiviteye katılım motivasyonlarını, kognitif fonksiyonlarını, kas kuvvet ve enduranslarını, esnekliklerini, fiziksel uygunluk bilgi testi ve Fitnessgram test bataryası sonuçlarını geliştirdiğini ortaya koymuştur.

Tartışma: Brain Breaks® web tabanlı çevrimiçi video programının okul çocuklarında akademik performansı ve sağlıkla ilişkili fiziksel uygunluğu geliştirme potansiyeline sahip olduğu düşünülmektedir.

Anahtar Kelimeler: Tutum; Brain-Breaks; Bilişsel fonksiyon; Çocukluk; Fiziksel aktivite.

INTRODUCTION

Physical activity (PA) is considered an essential determinant for improving quality of life, adding to a healthy lifestyle, and reducing chronic disease risks such as hypertension, obesity, and diabetes (1-3). In addition, information found in the literature demonstrates that PA significantly influences various measures of cognitive performance and academic achievement among children (4, 5). A recent study by Xue et al., (6) suggests that long-term exercise programs used in school, sports, and PA programs may improve several areas of executive function, especially inhibitory control.

Despite the numerous health benefits associated with regular exercise, it remains an infrequent practice among large segments of the population in developed nations Radford et al. (7). For example, epidemiological studies highlight that a majority of American adults fail to meet recommended exercise levels (8, 9). In addition, Nicklett et al., (10) found that physically inactive adults faced a 50% to 60% higher risk of premature death compared to their active counterparts. Globally, physical inactivity contributed to 9% of deaths, while sedentary behavior was associated with 3.8% of deaths (11, 12).

According to the World Health Organization (WHO), children should engage in daily moderate-to-vigorous PA (MVPA) for 60 minutes (13). Despite the documented PA benefits (1), a significant portion of adolescents are sedentary, and PA is decreased during adolescence, with the decrease being greater in females than in males (2). Sedentary behavior refers to any waking behavior that involves an energy expenditure of less than 1.5 metabolic equivalents while in a sitting, reclining, or lying position (13). Berkey et al. (14) report that more time engaged with on-screen entertainment is associated with substantial increases in male and female children's body mass index (BMI). This negative lifestyle change is becoming a serious concern as childhood obesity is on the rise in most countries (15). The results of a meta-analysis demonstrate that the most effective approach to promoting and maintaining PA behaviors is through behavioral intervention (16).

In recent years, educational technology tools have gained greater utilization to facilitate teaching, learning, and behavioral change (17). The use of technology-assisted communications to administer and enhance medical and psychological treatments initially emerged in 2000 and has since become widely used (18). The perception that technology, such as web-based information delivery, online chat rooms, mobile devices, and video conferencing, has the potential to improve the efficacy of targeted interventions and comprise more universal and at-risk populations is what is driving this explosive growth (19). In particular, using technology can motivate students to raise their PA levels (20). For instance, technology such as online streaming, HOPSports Brain Break® videos, and virtual reality games like Pokemon GO were created to boost students' and adults' PA participation (21). In this review, we focused on the HOPSports Brain Breaks® video because this programming makes use of a dynamic online platform that is consistent with the Whole School, Whole Community, and Whole Child (WSCC) Guidelines and the 17 United Nation Sustainable Development Goals (UNSDG 17) (22, 23).

Brain Breaks® intervention (https://brain-breaks.com/) contributes to achieving the health and well-being targeted goals presented by the UNSDG's 17 Sustainable Development Goals, utilizing an average duration of three to five minutes each to promote and enhance positive PA behaviors among children and adolescents (24-27). Good health and well-being, high-quality physical education, PA interventions in schools, encouraging community PA actions, and active transportation are all included in the UNSDG goals, particularly in relation to targets 3, 4, and 11. These programs are easily accessed via the Internet. Only a school projector and internet access are needed for program implementation (22). Brain Breaks® programming and videos were initially introduced by HOP-Sports, are supported by The Foundation for Global Community Health (http://www.gchfoundation.org), and have been adopted by 70 countries (22). HOPSports®, Inc.'s ready-made safety, health, and educational solutions are used by schools, colleges, community-based groups, hospitals, recreation centers, and treatment facilities. HOPSports provides opportunities for increased physical activity, nutrition, and character education as part of its programs designed to support students' welfare, academic performance, and overall health.

Brain Breaks® is designed as a classroom activity in addition to the schools' normal physical education curriculum. Emeljanovas et al. (28) state that physical education should not be regarded as bodily movement alone but as a comprehensive educational philosophy promoting educational continuity, self-reliance, and competency among children. Brain Breaks® programming and videos are usually applied twice daily, five days a week, throughout the academic year, and the results from studies using this intervention show that Brain Breaks® videos promoted positive children's attitudes toward PA, mental health, learning ability, and academic achievement (29-33). Mok et al. (34) found that when Brain Breaks® intervention programming was applied twice daily, five days a week, for four months, children's attitude toward PA increased. In addition, Krause and Benavidez (35) reported that technology-based programs are more likely to improve PA participation in children as compared to non-technology-based games and sports. Furthermore, Primack et al. (36) found that video games positively affect health education outcomes by 42%, and digital programs such as Brain Breaks® enhance cognitive achievement with PA self-motivation, improving positive health behaviors (22, 31).

Active breaks are 5- to 15-minute MVPA sessions facilitated by teachers incorporating brief intervals of PA in conjunction with academic lessons. Active breaks do not need specialized staff or unique locations and equipment, so they can be implemented in any kind of educational setting (37, 38). Early Brain Breaks® research studies (e.g., (24, 34)) report that breaking up sit-time with PA during the school day contributed to improved student attention, enhanced knowledge acquisition, general alertness, on-task behaviors, self-awareness, and improved PA engagement. Brain Breaks® research has also demonstrated the potential for improving children's academic understanding of music, language, culture, and art (22), as well as maintaining behavioral change (39).

Despite the diverse findings for Brain Breaks® technology, several research questions remain unanswered: 1) What are the effects of Brain Breaks® video programming on children's physical fitness and their attitude toward PA (i.e., perceived benefits, importance, learning, self-efficacy, fun, fitness, and personal best)? 2) What methods are best used in Brain Breaks® intervention studies? 3) What age groups were used or evaluated in Brain Breaks® intervention studies? 4) Where have the Brain Beaks® intervention video program and its effects been utilized across the globe? 5) Have Brain Breaks® intervention studies been conducted among children of different races and ethnicities? 6) What are the estimated sample sizes from past studies? 7) What outcome measures were used to assess the effect of the Brain Breaks® video programming?

Given the diverse intervention findings regarding the use of Brain Breaks® programming and videos and that the findings are consistent with UNSDGs for good health, a need exists for a comprehensive systematic review of the present literature to develop clear and specific conclusions and recommendations concerning Brain Breaks® programming and video effects on health-related outcomes. Furthermore, Brain Breaks® programs are interactive web-based structured videos on nutrition, hygiene (lifestyles), and physical exercise that are designed to improve students' interest in learning and promote better health (40). Therefore, the purpose of this review is to provide a comprehensive, systematic review of the impact of Brain Breaks® programs and videos on academic performance and outcomes related to health in school-aged children. This review will lend support to the necessary investigation to assess and deepen our understanding of Brain Breaks® programs and videos, as well as beneficially influence the UNSDGs about children's health and wellbeing.

METHODS

Study Design

This review utilized the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) Search Strategies (41). The review was registered in the International Prospective Register of Systematic Reviews (PROSPERO; record #CRD 42022315938). The ethical approval was granted by the Universiti Sains Malaysia's Human Research Ethics Committee (USM/JEPeM/21050370). A literature search for relevant studies was conducted between January 2024 and February 2024. The electronic databases searched were PubMed, ScienceDirect, Scopus, ResearchGate, and Google Scholar. Search keywords used were combinations of the following: (1) Brain Breaks®; music, culture, and language, (2) Brain Breaks®; PA, (3) Brain Breaks®; academic performance, (4) Brain Breaks®; health, (5) Brain Breaks®; UNSDG, and (6) Brain Breaks®; motives and attitudes toward PA. In PubMed, the search string used was "Brain Breaks®" or Brain Breaks video technology) OR "Brain Breaks® physical activity intervention" OR "Brain Breaks® video intervention." [Title/Abstract/Keywords] AND (schoolchildren) [Title/Abstract/Keywords] AND (effect of Brain Breaks® on physical activity, academic performance, achievement, cognition, motivation, attitude, and self-efficacy); ScienceDirect, [Title/Abstract/Keywords] AND (child* OR school-age OR schoolchildren); in Scopus, [Title/Abstract/Keywords] AND ("experimental studies [Title/Abstract/Keywords]; in ResearchGate, "Brain Breaks" AND "physical activity" AND "academic performance" AND "health outcomes"; and in Google Scholar, "Brain Breaks" "physical activity breaks" "academic performance" "health outcomes". Some search words were changed in accordance with the specifications of the database. The reference lists of the included reviews were searched, and the search was conducted without any restrictions. Two authors searched from its inception until December 2023.

Eligibility Criteria

The inclusion criteria for articles used in this review were: 1) studies conducted among schoolchildren regardless of ethnicity, country, or health condition; 2) experimental studies that tested the effect of Brain Breaks® programming and videos; 3) studies related to Brain Breaks® and outcomes related to health such as PA and academic achievement; and 4) reports on Brain Breaks®. Reports considered eligible were: 1) the articles published in English; and 2) Publications from Brain Breaks® programming between the year of launch and December 2023. Exclusion criteria were non-experimental studies, studies conducted on adults, and studies conducted on non-school children.

Data Extraction

The Cochrane Consumers and Communication Review Group's template (42) was used to extract data, and all authors contributed to the data extraction process. For example, the Cochrane Consumers and Communication Review Group has created this template for its review authors. The template aims to collect all relevant details about the included studies and their outcomes. The template consists of seven sections: general review information, study methods, risk of bias assessment, study characteristics (participants), study characteristics (interventions and comparisons), study characteristics (outcomes), and data and results. Data extraction and review were initially completed by two investigators (GK and AS). Studies deemed not relevant based on the review of the title and abstract were excluded. Conflicts were solved by a third reviewer (YCK). The articles selected in the previous step were read in full-text version and checked again on the eligibility criteria (GK and AS). Any disagreements were solved by a third reviewer (YCK). In addition, the remaining authors reviewed the quality of the final data collection and entry. Information extracted from the retrieved studies were a) characteristics of participants (sample size, gender, and age); b) study design; c) country where the study was completed; d) follow-up time in week or month (Brain Breaks® intervention period); and e) study outcome.

Risk of Bias Assessment

In this review, we applied the ROBINS-I ("Risk of Bias in Non-randomised Studies—of Interventions"), which is concerned with assessing the risk of bias in estimates of the effectiveness or safety (benefit or harm) of intervention from studies that did not use randomization to allocate interventions, since 16 of the included studies used a non-randomized design (43). Two independent investigators assess the methodological quality of the included studies. The risk of bias was assessed using seven domains: 1) Bias due to confounding, 2) Bias in selection of participants into the study, 3) Bias in classification of interventions, 4) Bias due to deviations from intended interventions, 5) Bias due to missing data, 6) Bias in measurement of outcomes, and 7) Bias in selection of the reported result. The research was classified as “low risk of bias.” If the study is judged to be at low risk of bias for all domains; “moderate risk of bias” if the study is judged to be at low or moderate risk of bias for all domains; “serious risk of bias” The study is judged to be at serious risk of bias in at least one domain, but not at critical risk of bias in any domain; “critical risk of bias” The study is judged to be at critical risk of bias in at least one domain; and “no information” if there is no clear indication that the study is at serious or critical risk of bias and there is a lack of information in one or more key domains of bias (43). In this review, we rated 13 studies as “low risk” due to the clear definition and consistent application of the intervention (Brain Breaks®) across all participants, while we rated 3 studies as “moderate risk” due to inadequate control for socioeconomic status, which could influence both physical activity levels and academic performance.

RESULTS

Criteria for relevant articles concerning the effect of Brain Breaks® followed the PRISMA guidelines (see Figure 1) (35). A total of 2338 records were identified using Google Scholar, PubMed, Scopus, Web of Science, and ResearchGate databases, and seven additional records were identified through other sources. All duplicate records were removed (n = 818), leaving 1520 records. After screening for the title and abstract content was completed, 40 studies were identified. We excluded 20 out of these 40 studies because they did not meet the study inclusion criteria, which included non-experimental studies, studies conducted on adults, and studies conducted on non-school children. A total of 20 studies were considered eligible and relevant to the research objectives for this review. Five more articles were excluded after reading the full text. Articles removed were published by Kuan, Rizal (22), Dinc, Saçlı Uzunöz (24), Mok, Chin (26), Hidrus, Kueh (44), and Hidrus, Kueh (45). One article is an update concerning Brain Breaks®; two articles tested the psychometric properties of attitudes toward PA scores on the attitude toward physical activity scale (APAS); and the two articles from Hidrus concern Type-2 Diabetic patients.

A total of 15 studies (23, 28, 29, 34, 39, 40, 46-54) presented in Table 1 between December 2017 and December 2023 were identified, and of these studies, nine reported the positive effects of Brain Breaks® on attitude towards PA using APAS, two reported the positive effects of Brain Breaks® on PA level, whereas the remaining studies reported the positive effects of Brain Breaks® on students' academic performance, perceived pros and cons of PA, TTM constructs, motivation for PA participation, muscle strength, muscular endurance, and flexibility fitness knowledge test for children, and the fitnessgram test battery. Furthermore, of the nine studies included in the analysis using APAS to measure outcomes, six studies employed APAS using the seven constructs developed by Mok, Chin (26), including benefits, importance, learning, self-efficacy, fun, fitness, and personal best.

Regarding studies that used APAS, eight of the nine studies reported a significant increase in the mean scores of all APAS constructs with time in the experimental group compared to the control group (i.e., benefits, importance, learning, self-efficacy, fun, fitness, and personal best). In the remaining study by Glapa et al. (40), three scales (i.e., benefits, self-efficacy, and fun) increased their means with time in the experimental group. For students' motives for PA participation, a significant improvement in their enjoyment, competitiveness, appearance, and psychological condition was observed, whereas no significant improvement was detected in mastery, affiliation, or physical condition. Two studies reported PA level as an outcome; one study reported a small, non-significant increase in energy expenditure during the school day and also a non-significant increase in sedentary time. The remaining study reported that during the intervention, children's sedentary behavior significantly decreased, while vigorous PA significantly increased. For TTM, changes with time in cognitive process, behavioral process, and internal feeling were found. Also, a significant difference between groups on cons existed.

A review of the literature revealed that 14 of the 15 included studies used a quasi-experimental design and the remaining study used a randomized controlled trial (RCT) design. Of the 15 studies, nine employed an intervention period of three months, four studies utilized an intervention duration of four months, and the remaining three studies used an intervention of six to ten weeks. Furthermore, 14 of the 15 included studies investigated the group effect (control and experimental) and the time effect (follow-up time), while the remaining study investigated only the time effect of Brain Break programming.

Within the 15 selected studies, five studies were conducted in Malaysia, four studies were conducted in Türkiye, three studies were conducted in South Africa, two studies were conducted in a study carried out in Croatia, Lithuania, Macedonia, and Poland, and one study was conducted in a study carried out in China, Singapore, Romania, Slovakia, and Serbia. The study sample size ranged from 48 to 3036 subjects, and the mean participant age ranged from 6.0 to 12 years.

DISCUSSION

The present manuscript presents a comprehensive literature review evaluating the health effects of Brain Breaks® programming and video as a PA intervention for children. The findings support the use of this intervention to achieve the health and well-being target goals presented by the UNSDG (24-27), especially goals 3, 4, and 11, which refer to good health and well-being, quality physical education, PA interventions in schools, promoting community PA actions, and active transportation. This review confirms that Brain Breaks® is becoming globally available through the internet and easily accessible in situations such as the pandemic when individuals do not have easy access to outdoor activities. With ease of use in any environment, studies reviewed show these online exercise videos offer comprehensive education opportunity that incorporates cultural knowledge, PA, and music.

The findings of this review reveal that 14 of the 15 studies used a quasi-experimental design. RCTs, on the other hand, are the most reliable method to examine the effectiveness of new treatments or interventions (55), while the quasi-experimental design is more suitable for estimating the effect of an intervention when repeated measures design or analysis is used and pre-post testing is used (56, 57). Also, all of the 15 studies that employed a quasi-experimental design used a repeated measures design. The intervention time for the Brain Breaks® application ranged from one week to four months, and the findings of this review support Brain Breaks® as providing a positive effect on academic performance and health-related fitness outcomes.

The children's mean ages in this literature analysis ranged from 6.0 to 12 years. This age range illustrates that all studies included in this review investigated the effect of Brain Break programming among schoolchildren. Previous studies reported that Brain Breaks® videos promote students' self-efficacy, learning, self-awareness, participation, concentration, and attitude toward PA (28, 40, 47, 52). Additionally, the findings of this review show that Malaysia had the most Brain Breaks® studies, followed by Türkiye and South Africa. These findings show that while the Brain Break programming effectiveness has been investigated throughout the globe, most research studies were carried out in Asia and Europe. This observation suggests that Brain Break programming has to be investigated further in various other regions of the world. Furthermore, individual study sample sizes ranged from 48 to 3036 subjects, supporting that Brain Breaks® programming and video intervention have a broad application among schoolchildren.

The results of this review demonstrate that Brain Breaks® programming and videos have positive effects on attitudes towards PA participation measured using APAS. The APAS was developed by Mok, Chin (26) in English and is a valid and reliable questionnaire to measure primary schoolchildren's attitudes towards, perceptions of, and beliefs about various aspects of PA engagement, with a focus on PA using video games. The scale covers seven sections, including promoting holistic health; the importance of exercise habits; self-efficacy in learning with video exercises; self-efficacy in selecting video exercises for themselves; exercise motivation and enjoyment; self-confidence in physical fitness; and trying to do my personal best. To ensure the validity and comparability of the data gathered, some authors applied the APAS questionnaire in its English version while other countries translated APAS to different languages, reviewed the questionnaire for cultural appropriateness, and made any necessary modifications, including China (3), Lithuania (28), Macedonia (52), Malaysia (29), Poland (40) and Türkiye (49). However, all translated versions had the same number of constructions and items as the original English version. Future research should homogenize both the interventions and the assessments (with the same instruments). Developing a bio-psycho-social study—that is, considering sociological difficulties in addition to psychological and physiological aspects is of interest.

A study by Bonnema et al. (47) found that before the intervention program, there was no difference in attitudes towards physical activity (PA) and fitness between the control and experimental groups, except for the importance of PA. After completing the HOPSports Brain Breaks® intervention program, the experimental group showed statistically and practically significant improvements in their attitudes towards PA and fitness. These improvements included attitudes towards the benefits of PA, self-efficacy in using video exercises for PA, and attitudes towards environmental support and interest in PA, indicating a dramatic positive shift in their perspectives. These findings align with a study by Mok, Chin (58) involving 2,751 learners from Grade 3 to Grade 5 across seven countries: Türkiye, Serbia, Croatia, Romania, Poland, Lithuania, and South Africa. The constructs with the strongest effect sizes were self-efficacy in using video exercises for PA, followed by attitudes towards the benefits and importance of PA. Similarly, Uzunoz et al. (49) reported significant improvements among 300 Grade 3 to Grade 5 learners from Türkiye in self-efficacy in using videos, personal best, importance of PA, self-confidence in physical fitness, and motivation and enjoyment of PA.

While various mobile applications and online video platforms are available to promote PA participation in children, Brain Breaks® programming and videos are online classroom-based videos with experimental data supporting improved children's interest and cognitive function (59). The benefits of Brain Breaks® on cognitive functions are supported by the association between exercise and cognitive function (60). WHO guidelines regarding PA and sedentary behaviors indicate that regular PA benefits mental health and cognitive functions, including academic performance and executive function in children (13). PA Guidelines for Americans (61), provide further support for cognitive function benefits and performance on academic achievement tests, executive function, mental processing speed, and memory in children aged 6 to 13 years. These guidelines are based on perspectives obtained from studies concerning a single exercise session and long-term practiced PA or exercise (61). Exercise is known to positively affect cognitive function (59, 62), regardless of age (63), and includes children with special conditions (e.g., attention deficit and hyperactivity disorder) (59, 64).

This review reveals changes with time in cognitive processes, behavioral processes, and internal feelings. Other studies using neuro-electrical instruments, event-related potential (ERP), electroencephalography (EEG), functional Magnetic Resonance Imaging (fMRI), and measurement of neuropsychological biomarkers such as memory or cognitive function provide insight into the mechanisms and confirm the relationships between PA, exercise, and brain health. For example, a single exercise session induced a larger P3 amplitude of ERP in preadolescents (65) and children (66), suggesting that more attentional mental resources become available when individuals are engaged in cognitive tasks (65). The upregulation of neurochemicals, such as neurotrophins (e.g., brain-derived neurotrophic factor [BDNF]), following PA or exercise, provides another exercise benefit because BDNF activity plays a crucial role in neuron transmission, modulation, and plasticity. These physiological responses influence cognitive functions (66).

Incorporating PA into academic lessons (e.g., students need to incorporate PA into other academic areas such as in math), scheduling brief (5–15 minute) PA breaks between lessons (e.g., having students follow a sequence of exercises), or incorporating PA into main transition periods (e.g., having students hop around the classroom before getting in line to go to lunch) are the three main approaches that have been used to include PA during school time (37, 38). The novelty of Brain Break is the diverse cultural features included in the videos such as traditional dance specific to each country, sports, and contemporary movements (52). Brain Breaks provides teachers with a wide selection of PA videos to choose from while adding classroom variety (28). These videos often result in improvements in students' PA attitudes and self-esteem, and students are provided the opportunity to master new motor skills (28).

The use of Brain Breaks® programming is relatively new, and few studies related to its efficacy exist. Given that most of the existing studies examined the effect of this program on PA and students' academic performance, future studies should examine the effect of Brain Breaks® on other health-related outcome measures such as anxiety, depression, emotional control, and exercise endurance. This observation is meant to encourage interested researchers to explore the direct and mediating effects of Brain Breaks® on many health-related outcomes (for example, disease risk, cardiorespiratory fitness, muscle strength, endurance, flexibility, and body composition). A need exists to implement Brain Breaks® intervention in various parts of the world, across a wide range of age groups, and to examine various mechanisms for change like the studies performed by Chu et al. (65) and Chang et al. (66). Future research studies will continue to create awareness and provide additional information for policymakers about the benefits of online video programming, and studies should be designed to provide information and insight into the mechanism responsible for change and how to better utilize this web-based video intervention. A main limitation of the studies reviewed was that most studies used non-randomization designs (quasi-experimental designs). However, given that all studies used repeated measures of statistics, study outcomes are considered reliable (55).

For future research investigations, the potential exists to advance the understanding of online videos and cognitive function via systematic exploration. Chang et al. (67) proposed a 3W1H framework, representing the three "Ws" (i.e., what, who, when) and one "H" (i.e., how), to consider the relevance of sequential studies associated with a single exercise session, regularly practiced exercise and cognitive function. Systematic investigations using this framework will further advance the knowledge base regarding the optimization of a single exercise session and regularly practiced exercise, and the PA effects on cognitive function and brain health in children while establishing a stronger foundation for understanding and customizing exercise programming and prescriptions.

The findings of this review illustrate the importance of online video programming as a web-based intervention designed to promote better health for schoolchildren by improving their attitudes toward PA, motives for PA, short-term memory, perceived pros and cons of PA, PA level, and TTM constructs, cognitive, affective, and behavioral components of students' attitudes toward physical activity, muscle strength, muscular endurance, and flexibility fitness knowledge test for children, and the fitnessgram test battery. Most importantly, Brain Breaks® intervention programming provides a means to achieve the health and well-being target goals presented by the UNSDG. Future studies should consider studying the effect of the Brain Breaks® intervention across various cultural and gender differences as well as other health-related outcome measures such as anxiety and depression. Finally, as studies are being designed and implemented, consideration should be given to using outcome measures such as physiologic and biochemical variables to gain new insight into the physiologic and biochemical mechanisms responsible for changes brought about by online video intervention.

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Table 1. Summary of Existing Literature Relating to Brain-Breaks Research

Author	Study design	Characteristics of intervention	Country/characteristics of participants	Follow-up time	Follow-up time Mean±SD/%	Study outcome [measurement scale]	Risk of bias
Balasekaran et al. (46)	Quasi-Experimental	Classroom-based Brain Breaks® Physical Activity Solution, averaging three-five minutes daily during their class time, five days per week.	Singapore (n = 113) M = 47 F = 66 Mean age = 9.68	10 wks.	CG Pre-Post F1: 3.19±0.55-3.13±0.64 F2: 3.28±0.61-3.32±0.60 F3: 2.77±0.78-2.32±0.88 F4: 3.10±0.60-2.82±0.74 F5: 3.18±0.58-3.19±0.66 F6: 3.05±0.73-3.07±0.69 F7: 3.29±0.65-3.32±0.63 EG F1: 3.06±0.51-3.61±0.37 F2: 3.29±0.52-3.74±0.31 F3: 2.65±0.67-3.64±0.36 F4: 3.02±0.62-3.62±0.51 F5: 3.17±0.48-3.58±0.38 F6: 2.97±0.73-3.65±0.39 F7: 3.20±0.61-3.66±0.43	APAS [Attitudes toward Physical Activity Scale]	LR
Bonnema et al. (47)	Quasi-Experimental	Brain Breaks® intervention program once a day.	South Africa (n = 114) M = 56 F = 58 Mean age (EG) = 11.4 Mean age (CG) = 11.71	3 mo.	CG Pre-Post F1: 3.16±0.42-3.19±0.47 F2: 3.51±0.43-3.07±0.73 F3: 2.42±0.55-2.38±0.70 F4: 2.72±0.70-2.86±0.70 F5: 3.19±0.48-3.07±0.43 F6: 3.35±0.52-3.11±0.65 F7: 3.53±0.51-3.12±0.58 EG F1: 3.9±0.42-3.72±0.29 F2: 3.34±0.44-3.53±0.40 F3: 2.32±0.95-2.58±0.68 F4: 2.63±1.11-3.42±0.42 F5: 3.26±0.46-3.60±0.37 F6: 3.23±0.57-3.61±0.40 F7: 3.39±0.58-3.50±0.47	APAS [Attitudes toward Physical Activity Scale]	LR
Bulca et al. (48)	Quasi-Experimental	The experimental group received PE lessons once per week with the BB PA program and extra videos at home three days a week, while the control group received routine PE lessons during this period.	Türkiye (n = 62) Mean age = 10.48 (EG) and 10.59 (CG)	8 wks	EG Pre-Post FKTC: 19.18±3.37-30.04±4.29 20-M shuttle run: 22.61±7.56-25.04±6.13 Sit-reach (cm): 19.04±7.00-28.71±7.08 Sit-up test: 23.89±5.69-31.64±5.45 Push-up test: 18.93±4.49-23.00±4.68 Heart rate (Bpm): 144.96±18.10-137.80±5.40 CG Pre-Post FKTC: 21.47±3.75-28.59±3.95 20-M shuttle run: 24.76±6.74-24.94±4.02 Sit-reach (cm): 18.29±5.02-26.52±6.29 Sit-up test: 24.38±4.69-31.85±4.40 Push-up test: 19.29±4.21-21.82±6.54 Heart rate (Bpm): 138.76±17.00-140.60±15.20	Fitness Knowledge Test for Children and the Fitnessgram Test Battery	MR
Emeljanovas et al. (28)	Quasi-Experimental	Brain Breaks video exercise intervention every school day in their classrooms during class breaks.	Lithuania (n = 181) M = 98 F = 83 Mean age = 8.54	3 mo.	CG Pre-Post F1: 3.38±0.0.47-3.18±0.49 F2: 3.35±0.49-3.22±0.45 F3: 1.92±0.64-1.84±0.60 F4: 2.88±0.81-2.64±0.83 F5: 2.16±0.66-1.98±0.70 F6: 2.82±0.34-2.62±0.83 F7: 3.33±0.48-3.25±0.49 EG F1: 3.09±0.48-3.55±0.48 F2: 3.23±0.52-3.68±0.46 F3: 1.92±0.73-2.79±0.73 F4: 2.71±0.83-3.54±0.55 F5: 1.94±0.76-2.91±0.70 F6: 2.60±0.0.42-2.87±0.40 F7: 3.20±0.60-3.65±0.46	APAS [Attitudes toward Physical Activity Scale]	LR

Glapa et al. (40)	RCT	Brain Breaks® videos two times per day in three to five minutes.	Poland (n = 326) M = 170 F = 156 Mean age = 9.7	4 mo.	CG: Pre-Post Promoting holistic health: 2.9±0.47-2.8±0.63 Importance of exercise habit: 3.3±0.56-3.2±0.68 Self-efficacy in learning: 1.5±0.86-0.8±0.75 Exercise motivation and enjoyment: 2.9±0.47-2.8±0.75 Self-confidence in physical fitness: 2.9±0.73-2.9±0.85 Trying to do personal best: 3.2±0.58-2.9±0.99 EG: Pre-Post Promoting holistic health: 3.0±0.56-3.1±0.60 Importance of exercise habit: 3.3±0.81-3.3±0.67 Self-efficacy in learning: 1.7±1.03-2.6±0.71 Exercise motivation and enjoyment: 3.0±0.58-3.1±0.65 Self-confidence in physical fitness: 3.1±0.69-3.1±0.77 Trying to do personal best: 3.2±0.77-3.2±0.87	APAS [Attitudes toward Physical Activity Scale]	-
Hajar et al. (29)	Quasi-Experimental	Brain Breaks® videos five times per day in three to five minutes.	Malaysia (n = 335) M = 159 F = 176 Mean age = 10.51	4 mo.	CG Pre-Mid-Post Enjoyment 13.93±4.37-13.04±4.08-12.18±4.19 Mastery: 12.85±3.42-12.72±3.54-12.65±.62 Competition: 11.36±3.63-11.88±3.46-11.80±3.59 Affiliation: 11.63±3.12-12.23±3.66-12.35±2.88-12.02±3.20 Appearance: 14.92±3.51-14.06±3.57-13.44±3.57 Physical: 13.45±3.56-13.06±3.50-13.06±3.51 Psychological: 13.12±4.02-12.90±3.41-12.07±3.41 EG Pre-Mid-Post Enjoyment: 12.29±3.24-12.28±3.18-11.81±3.06 Mastery: 12.31±2.98-12.10±3.01-12.29±2.66 Competition: 10.65±3.37-10.84±2.94-11.98±3.24 Affiliation: 11.63±3.12-11.75±2.92-12.15±2.96 Appearance: 13.64±3.64-13.77±3.08-13.93±2.99 Physical: 12.79±3.76-13.31±3.31-12.82±3.42 Psychological: 12.18±3.37-13.03±3.20-12.73±2.81	Motives of participation in PA [Physical Activity and Leisure Motivation Scale-Youth-Malay (PALMS-Y-M)]	LR
Lim et al. (50)	Quasi-Experimental	Brain Breaks® videos	Malaysian (n = 70) M = 33 F = 37 10-12 years	-	M EG Pre-Post 3-min step test: 96.13±13.01-88.13±12.48 Push-ups: 13.56±3.05-15.56±3.24 Curl-ups: 16.50±1.90-18.75±2.11 Sit and reach: 25.56±5.07-26.37±6.68 CG Pre-Post 3-min step test: 105.82±16.80-109.94±19.54 Push-ups: 11.71±4.77-11.65±4.60 Curl-ups: 14.18±3.52-15.00±2.50 Sit and reach: 23.79±5.95-24.85±6.00 F EG Pre-Post 3-min step test: 111.32±24.98-103.89±23.86 Push-ups: 14.16±3.47-16.68±2.87 Curl-ups: 15.47±1.68-17.74±1.73 Sit and reach: 28.06±5.11-28.74±6.79 CG Pre-Post 3-min step test: 105.67±21.52-111.89±23.88 Push-ups: 15.89±5.06-14.78±4.57 Curl-ups: 13.78±4.31-13.83±3.31 Sit and reach: 27.33±4.99-27.72±4.19	Muscle strength, muscular endurance, and flexibility using a 3-minute step test, push-ups, curl-ups, and sit-and-reach	MR

Mok et al. (34)	Quasi-Experimental	Brain Breaks® Videos were 3–5 minutes in length, presented two times per day, five days each week.	Eight countries: Croatia. Lithuania. Macedonia. Poland. Romania. Serbia. South-Africa. Türkiye. (N = 3036) M = 1496 F = 1540 Age range = 8 - 11	4 mo.	CG Pre-Post F1: 2.888±0.650-3.021±0.619 F2: 3.231±0.634-3.298±0.589 F3: 2.268±0.709-2.374±0.748 F4: 2.550±0.822-2.619±0.847 F5: 3.008±0.673-3.143±0.616 F6: 3.081±0.715-3.206±0.658 F7: 3.237±0.771-3.315±0.732 EG F1: 2.929±0.691-3.235±0.538 F2: 3.246±0.659-3.452±0.536 F3: 1.997±0.827-2.681±0.696 F4: 2.288±0.997-3.219±0.624 F5: 3.068±0.686-3.271±0.593 F6: 3.164±0.692-3.322±0.590 F7: 3.203±0.811-3.399±0.658	APAS [Attitudes toward Physical Activity Scale]	LR
Podnar et al. (51)	Quasi-Experimental	Five-minute PA daily was performed in the middle of a 45-minute academic lesson by imitating video animations projected on the Brain Breaks® Physical Activity Solutions.	Croatia (n = 98) Age range = 6 - 10	12 wks.	Pre-Post TEE: 257.88±10.57-281.79±11.85 Steps: 2717.51±109.55-2868.79±122.87 Sedentary: 177.46±3.28-181.59±3.68 Moderate: 19.09±1.48-19.09±1.664 Vigorous: 6.79±1.05-7.224±1.18 METs: 2.32±0.08-2.392±0.09	PA level [SenseWear Armband Body Monitor (BodyMedia Inc., Pittsburgh, PA, USA)]	LR
Popeska et al. (52)	Quasi-Experimental	The active breaks were applied each school day for 3–5 minutes, five days per week, during one particular class selected by the teacher.	Macedonia (n = 283) M = 155 F = 128 Mean age = 9.21	3 mo.	CG Pre-Post F1: 2.93±0.58-2.90±0.61 F2: 3.30±0.56-3.34±0.62 F3: 2.60±0.76-2.63±0.75 F4: 2.83±0.68-2.79±0.73 F5: 3.17±0.61-3.22±0.62 F6: 3.16±0.63-3.28±0.65 F7: 3.39±0.59-3.46±0.58 EG F1: 3.12±0.77-3.38±0.51 F2: 3.58±0.58-3.70±0.46 F3: 2.88±0.87-3.07±0.87 F4: 3.16±0.72-3.62±0.50 F5: 3.48±0.56-3.58±0.49 F6: 3.47±0.59-3.56±0.51 F7: 3.62±0.51-3.74±0.41	APAS [Attitudes toward Physical Activity Scale]	LR
Rizal et al. (39)	Quasi-Experimental	The students were given the Brain Breaks Physical Activity Solutions intervention video for an accumulated time of 30 minutes per week.	Malaysia (n = 322) M = 159 F = 163 Mean age = 10.53	12 wks.	CG Pre-Post Stages of change: 3.35±1.21-3.07±1.23 Pros: 15.79±4.25-14.32±4.61 Cons: 12.40±4.16-13.16±4.64 Cognitive process: 25.36±5.77-23.81±6.77 Behavioral process: 38.90±11.81-38.70±11.20 Internal feeling: 11.28±4.21-11.36±4.44 Situational: 9.79±3.89-10.35±3.99 Competing demand: 10.28±3.72-10.39±3.53 Total METs: 66.54±27.27-67.38±27.20 EG Pre-Post Stages of change: 3.03±1.15-3.18±1.04 Pros: 14.07±3.81-15.22±3.51 Cons: 11.66±3.93-11.87±3.56 Cognitive process: 24.52±5.66-24.23±5.67 Behavioral process: 36.56±10.21-39.86±9.23 Internal feeling: 11.08±3.75-12.27±3.94 Situational: 9.90±3.75-10.28±3.71 Competing demand: 9.64±3.17-10.30±3.26 Total METs: 61.55±25.13-64.09±25.15	TTM (process of change, decisional balance, and self-efficacy) [stages of change questionnaire, process of change questionnaire, decisional balance scale, self-efficacy scale, and Godin Leisure-Time Exercise Questionnaire (GLTEQ)]	LR

Tománek et al. (53)	Quasi-Experimental	a 5-minute physical activity break during a random lesson every school day.	Slovakia (n = 229) M = 106 F = 123 Mean age = 11.18	3 mo.	M EG Pre-Post Cognitive: 23.72±4.72-24.31±4.34 Affective: 24.68±6.91-26.32±5.99 Behavioral: 25.12±5.91-25.82±5.33 CG Cognitive: 24.16±4.71-22.88±5.22 Affective: 23.10±7.68-21.06±6.79 Behavioral: 23.10±6.70-22.00±5.89 F EG Pre-Post Cognitive: 23.64±5.10-23.83±5.31 Affective: 22.43±6.89-24.48±6.89 Behavioral: 24.31±6.31-24.95±6.82 CG Cognitive: 24.52±5.04-23.95±5.66 Affective: 24.91±6.81-23.88±7.13 Behavioral: 25.32±6.29-23.89±4.57	Cognitive, affective, and behavioral components of students' attitudes toward physical activity.	MR
Uzunoz et al. (49)	Quasi-Experimental	The students were given the Brain Breaks Physical Activity Solutions intervention video daily for an accumulated time of 3-5 minutes at various intervals.	Türkiye (n = 300) Mean age = 9.55	4 mo.	CG Pre-Post Self-efficacy in learning with video exercise: 2.11±0.62-2.11±0.42 Exercise motivation and enjoyment: 2.12±0.57-2.16±0.40 Self-confidence in physical fitness: 2.29±0.57-2.34±0.45 Promoting the holistic health: 2.41±0.67-2.44±0.47 Importance of exercise habit: 2.69±0.72-2.70±0.47 Trying to do personal best: 1.90±0.56-1.94±0.47 EG Pre-Post Self-efficacy in learning with video exercise: 2.12±0.65-2.62±0.34 Exercise motivation and enjoyment: 2.11±0.54-2.41±0.44 Self-confidence in physical fitness: 2.26±0.60-2.58±0.47 Promoting the holistic health: 2.39±0.66-2.78±0.50 Importance of exercise habit: 2.71±0.69-3.05±0.47 Trying to do personal best: 1.92±0.55-2.28±0.53	APAS [Attitudes toward Physical Activity Scale]	LR
van Stryp et al. (54)	Quasi-Experimental	10-minute classroom-based active brain-break intervention twice a week. The first active Brain Break took place early in the morning (between 08:15 and 08:45), and the second one later in the morning (between 10:30 and 11:00).	South Africa (n = 48) M = 28 F = 20 Mean age = 6.6	6 wks.	Overall (baseline) Sedentary: 106.2±30.9 Moderate: 43.7±13.7 Vigorous: 26.5±13.6 Overall (intervention) Sedentary: 100.1±20.0 Moderate: 41.9±11.6 Vigorous: 34.1±11.9	School PA Level (in minutes) [Wrist-worn Actigraph GT3X+ accelerometer (Actigraph LLC, Pensacola, FL, USA)]	LR

Zhou et al. (23)	Quasi-Experimental	Brain Breaks® video intervention for 3–5 min daily, at low-to-moderate intensity.	China (n = 704) M = 370 F = 334 Mean age = 9.24	3 mo.	CG Pre-Post F1: 2.70±0.58-3.031±0.49 F2: 3.08±0.50-3.15±0.49 F3:2.34±0.48-2.56±0.56 F4: 3.09±0.55-3.20±0.46 F5: 3.03±0.56 3.14±0.41 F6: 2.85±0.49-3.10±0.38 F7: 2.93±0.44-3.15±0.46 EG Pre-Post F1: 2.69±0.63-2.91±0.65 F2: 2.99±0.49-3.26±0.53 F3:2.42±0.63-2.65±0.77 F4: 3.14±0.54-3.17±0.58 F5: 3.04±0.54 3.28±0.50 F6: 2.90±0.48-3.23±0.47 F7: 2.99±0.50-3.36±0.54	APAS [Attitudes toward Physical Activity Scale]	LR

APAS = Attitude towards physical activity, CG = Control group, EG = Experimental group, F = Female, F1 = Benefits, F2 = Importance, F3 = Learning, F4 = Self-efficacy, F5 = Fun, F6 = Fitness, F7 = Personal best, TEE = total daily energy expenditure, FKTC = Fitness Knowledge Test for Children, LR = Low risk of bias, M = Male, mo = Month, MR = Moderate risk of bias, PA = Physical activity, SD = Standard deviation, Transtheoretical model (TTM) constructs = process of change, decisional balance, and self-efficacy in physical activity, yr = Year, wks = Weeks.