# Journal of Educational Psychology


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Online First Publication, November 17, 2025. https://dx.doi.org/10.1037/edu0000980

CITATION

Oppezzo, M., Schwartz, D. L., Aikens, R., Moore, J. B., Langford, J., Baiocchi, M., Gross, J. J., & Dohmen, I. (2025). Sit still or move more? The impact of fidgeting on creativity. *Journal of Educational Psychology*. Advance online publication. https://dx.doi.org/10.1037/edu0000980

AMERICAN PSYCHOLOGICAL ASSOCIATION

Journal of Educational Psychology


ISSN: 0022-0663

https://doi.org/10.1037/edu0000980

# Sit Still or Move More? The Impact of Fidgeting on Creativity

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Many modern classrooms impose constraints on student movement, both physical (e.g., stable, upright chairs) and psychological (e.g., norms that "being still" signals paying attention). We conducted two separate studies with 32 sixth-grade (11- to 12-year-old) and 43 seventh-grade (12- to 13-year-old) students. Study 1 was a within-subject design and compared students' creative ideation on the alternate uses test and a verbal memory task through two conditions: sit still (on a regular chair with instructions to not move) or freedom to move (on a wiggle stool with ability to move as they wanted). There was a significant effect of condition on novel ideas, as well as number of novel ideas/total ideation (creativity ratio). There was no significant difference by condition on the verbal memory task. Study 2 was a within-subject design. Because of the COVID-19 pandemic, each student completed two of three conditions: sit still, freedom to move, and sit as usual (on a regular chair with instructions to sit as if they were paying attention in class). This study compared students' creative ideation and a focused attention task instead of Study 1's memory task. There was a significant effect of condition on novel ideas and creativity ratio, but pairwise comparisons were not statistically significant. There was no condition effect on focused attention. The freedom to move effects appear selective only for creative ideation. Implications for future research and small classroom changes to support natural movement are discussed.

***Educational Impact and Implications Statement***

This research highlights the potential role of the classroom environment and movement for creativity in middle school children. Two studies examined the impact of seating that enabled versus restricted fidgeting, and instructions that emphasized staying still versus moving naturally. Giving students the "freedom to move"—especially with a stool that allows this—rather than adhering to traditional "sit still" norms increases creativity without diminishing memorization or paying attention. Ultimately, this is a first of its kind study that suggests the potential value of shifting toward more flexible environments that support natural movement behaviors of young learners.



Caitlin Mills served as action editor.

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This research was in part supported by the National Institutes of Health's National Heart, Lung, and Blood Institute under Awards K01HL136702 and T32 HL007034-39. The sponsors were not involved in any of the research or analyses. The authors declare that they have no conflicts of interest.



Marily Oppezzo served as lead for conceptualization, data curation, funding acquisition, investigation, methodology, writing–original draft, and writing–review and editing. Daniel L. Schwartz served in a supporting role for formal analysis, funding acquisition, writing–original draft, and writing–review and editing. Rocky Aikens served as lead for formal analysis, software, and visualization and served in a supporting role for writing–review and editing. Jessie B. Moore served in a supporting role for project administration, visualization, and writing–review and editing. Joss Langford served as lead for accelerometry and contributed equally to formal analysis and software. Michael Baiocchi served in a supporting role for formal analysis and methodology. James J. Gross served in a supporting role for methodology, writing–original draft, and writing–review and editing. Ilsa Dohmen contributed equally to investigation and served in a supporting role for funding acquisition and writing–review and editing. Marily Oppezzo and Ilsa Dohmen contributed equally to project administration and resources. Daniel L. Schwartz and Ilsa Dohmen contributed equally to conceptualization and methodology. Rocky Aikens, Jessie B. Moore, Joss Langford, and Ilsa Dohmen contributed equally to data curation.

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*Keywords:* dynamic seating, creativity, learning environments, movement

*Supplemental materials:* https://doi.org/10.1037/edu0000980.supp



Does giving students the freedom to fidget and wiggle enhance their creative thinking? Is there a price to pay in their memory or attention capacity? When asked to imagine the ideal classroom, many of us conjure a room filled with eager students who are sitting still and quiet in neat rows, attentively facing the teacher. The "sitting still" part of this image seems particularly salient. Teachers report that squirming, swinging on chairs, fidgeting, and whispering—what is classified as low-level classroom disruption—is a persistent, common, and ongoing challenge to behavioral management and learning. Not only are these low-level disruptions taxing to teachers, they also can be distractions to learning for the entire class, with some reports accounting for up to an hour a day of lost learning (Haydn, 2014; Ofsted, 2014; Skaalvik & Skaalvik, 2017).

Recent evidence, however, suggests that one behavior often subsumed under low-level classroom disruption, namely physical movement, may not be detrimental to education after all—and could even be helpful. Identifying if and how physical movement in the classroom interacts with learning and attention can help inform classroom behavior management and the design of modern classrooms. After a brief overview of the movement and learning literature, we situate the current two studies in the work on dynamic seating, where we explore the question of whether the freedom to fidget impacts cognitive outcomes including creativity, memorization, and attention.

## Sit Still or Move More?

High levels of student movement during class are often viewed as problematic (Campbell et al., 2002), suggesting a lack of student attention and general classroom disorder. Individual movement is part of a set of behaviors that are viewed as low-level classroom disruption. This makes intuitive sense, as giving students freedom to move without constraints can distract other students, for example, if a student is doing jumping jacks while another is focusing on reading a passage. Stillness is often lauded as a sign or even an "essential element" of attention (Carson et al., 2001; Langer, 1997), and classrooms have been historically designed for students to spend most of their school day seated in a hard-bottomed stable chair and being still.

Recently, both practitioners and educational researchers have questioned the boundaries of these assumptions. With public health priorities of both getting adequate exercise and interrupting prolonged periods of sitting, emerging research is exploring the integration of physical activity into the classrooms. We broadly categorize this work into structured, aerobic physical activity and unstructured, natural physical activity. We provide a brief outline of the physical activity and education literature below to then situate the current studies in the latter category of unstructured, natural physical activity.

## Structured, Aerobic Physical Activity

One area of study in physical activity and education involves structured, aerobic physical activity. Many public health studies investigate the learning impacts of students' exercise outside the class (e.g., sports or recess physical activity) and exercise breaks inside the classroom as a break from direct instruction. We classify these as "structured," because they are planned breaks when the activity is set to happen, and "aerobic" physical activity because the movements are exercise-like, and cause students' heart rates to increase beyond light physical movement like standing or walking. We subdivide the work as: (a) noncontent-coordinated physical activity, where the physical activity is not tied to what is being learned nor concomitant with the learning; and (b) content-coordinated physical activity, where the physical activity is integrated into the lesson and tied to the content of the lesson itself.

### *Noncontent-Coordinated Physical Activity*

With most of education being spent seated (both during learning and doing homework), advances in technology and video games, and increased television content, physical activity is largely engineered out of students' lives (Strasburger et al., 2010). Integrating breaks of physical activity into school has been shown to improve learning outcomes and executive function (Best, 2010; Strasburger et al., 2010). One randomized controlled trial with 9- to 12-year-old students showed that after a 10-min physical activity break, time on task was significantly higher compared to seated controls (Howie et al., 2014). Another showed 4 min of high intensity intervals improved selective attention in 9- to 11-year-olds compared to no activity breaks (Ma et al., 2015). Additionally, students who are more physically active outside of class are more likely to be engaged in lessons, though this is only an association (Goh et al., 2016; Owen et al., 2018; Watson et al., 2017). Exercise can also improve attention, especially in students with hyperactivity and attention challenges. One study showed that after just 5 min of aerobic exercise, math problem solving for students with inattention showed improvements in attention and task-related behavior (Molloy, 1989).

### *Content-Coordinated Physical Activity*

In contrast to structured physical activity that breaks up the seated lessons and is noncontent-coordinated, content-coordinated activity is where the movement is tied to the curriculum. An example of the former is a teacher having the students take a break from the math lesson to perform jumping jacks, whereas an example of the latter is a teacher having students do jumping jacks to demonstrate their answer to "$2 + 3$" (Bedard et al., 2019). Both led to superior enjoyment and memory when compared to a sedentary control in a three-condition study (Schmidt et al., 2019).

## Unstructured, Natural Physical Activity

In contrast to the structured, aerobic physical activity above, where activity may be prescribed by the context or teacher, another category of literature investigates the effects of unstructured, natural movement, where movement amount varies in degree and intensity by the student's own setpoint and proclivity. This physical activity is "unstructured" because it is not prescribed or organized, and "natural" because the nature and amount of movement are student-determined.

The combination of both of these features makes this category of physical activity in the classroom applicable to creating a "freedom to move" classroom environment where students are allowed to move according to their own setpoints and needs. Examples include active treadmill desks, fidgeting with fidget objects, or wiggling on dynamic chairs. We subdivide this work according to the movement type: (a) light physical activity, such as light walking or cycling using active desks during class; (b) fidgeting, where objects are provided for fine motor movement; and (c) dynamic sitting, using seats which allow for both bigger (e.g., rocking) and smaller (e.g., finger or toe tapping) muscle movements while remaining seated in class.

### *Light Physical Activity*

The work on thinking and concomitant light physical activity typically involves either walking meetings or the use of active desks. Studies on the effect of walking on cognition are largely with adults. One study found walking at a self-selected pace (natural) improved working memory compared to sitting (Schaefer et al., 2010). Relevant to the current study, a series of four studies demonstrated that adults showed improved divergent thinking specifically while they were walking at their self-selected, natural pace compared to while they were sitting (Oppezzo & Schwartz, 2014).

This work was added to by studies showing that free walking, not prescribed-path walking, led to the most benefit for divergent thinking (Kuo & Yeh, 2016). The authors suggest that this freedom to move is a necessary condition for the boost to freely flowing ideas. This was corroborated by Zhou et al.'s (2017) work showing increased divergent thinking on a design improvement task during unconstrained walking compared to constrained walking. These authors' explanation was different however. They suggest that unconstrained walking takes more cognitive control (presumably through making decisions about which path to take) which allows a defocusing, and therefore a relaxed filter on free-flowing ideas.

Active desks are desks with a seated bike, or treadmill attached with the main purpose of decreasing sedentary behavior; these are unstructured and let the user decide when to utilize the activity affordance in the desk. Like the work on walking, much of this work is in adults. Workstations showed increased psychological arousal, decreased boredom, and lower appraised task stress compared to sitting or standing (Sliter & Yuan, 2015). One systematic review suggests an increase in energy expenditure for walking desks, and increases in both inhibitory control and selective attention for cycling desks (Guirado et al., 2021). The review noted that many studies in this area lacked rigorous controls or designs. Additionally, several studies found no difference in walking compared to sitting in executive function, inhibition (Alderman et al., 2014; Larson et al., 2015), and performance on the Paced Auditory Serial Attention Test (Larson et al., 2015). Finally, for both younger and older adults, Marshall et al. (2021) found a faster reaction time walking compared to sitting on working memory tests, with no change in accuracy.

### *Object Fidgeting*

Fidget objects, popularized in the media but largely absent in research literature, are objects that allow for concurrent fine motor activity during academic task engagement. One theory of attention which may have inspired fidget objects dates back to 1955 (Leuba, 1955); optimal stimulation theory suggests that we seek to initiate stimulation-seeking activity, often through motor activity, when we are hypoaroused to maintain an optimal and homeostatic level of stimulation. Many fidget object studies are small ($n < 10$), with mixed findings. One small study on 9-year-old students with difficulties sustaining attention (but not diagnosed for attention deficit hyperactivity disorder (ADHD)) found playing with fidget cubes during math story problems reduced excessive motor movement and increased task completion, with no differences in problem accuracy (Kercood & Banda, 2012). Another study on third-graders (assumed 8- to 9-year-olds) showed lower performance of math problems when using a fidget spinner compared to not using one (Hulac et al., 2021). An argument against fidget objects is that they are visually stimulating objects that afford fine motor movement and therefore add to perceptual load; perceptual load theory notes that overtaxing perceptual systems can lead to memory and attentional impairments (Greene et al., 2017).

### *Dynamic Sitting*

Dynamic seating, or a chair which allows movement while being seated, enables small movements while limiting distractions for other students. The literature on dynamic seating in learning is mixed. Small studies have noted that stability balls can increase sitting time for students with ADHD (Fedewa & Erwin, 2011, no mention of medication; Schilling et al., 2003, each student was medicated), and both doodling and stability ball seating showed increased listening comprehension in students with ADHD than those without (Kercood & Banda, 2012, no student was medicated). However, one study found within-subject, stability ball seating decreased on-task activity for students compared to stable seating (Hulac et al., 2022). A study on class-wide outcomes documented no difference in on-task and out-of-seat behaviors between stable chairs and stability balls (Olson et al., 2019). These studies have spanned ages, included students with or without ADHD, and are either nomothetic (e.g., on-task behavior in general) or task-specific (e.g., listening comprehension).

## Present Research

The present research adds to the work in dynamic sitting and cognitive benefits. The goal of the present research was to explore, in middle school students, the selective cognitive impact of having both physical and psychological freedom to move via dynamic sitting compared to having to be still. There is evidence suggesting that the freedom to move increases divergent thinking compared to constrained movement or sitting (Kuo & Yeh, 2016; Oppezzo & Schwartz, 2014; Zhou et al., 2017). Previous literature has not directly connected dynamic sitting with divergent thinking. Dynamic seating offers an opportunity or freedom to move. We hypothesize that dynamic sitting will selectively boost divergent thinking. Our metric of choice is Guilford's alternate uses, which measures the generation of novel, alternative uses for common everyday objects. For example, what are different ways you can use a brick. Divergent thinking is a specific form of creativity, and it can be distinguished from other forms of creativity such as convergent thinking (Bowden & Jung-Beeman, 2003). For example, in the remote associates test of convergent thinking, people might need to find the single word that pairs with the three words "cottage—Swiss—cake" (answer: cheese). We chose to measure divergent thinking, as it expands on work by Oppezzo and

Schwartz (2014) showing walking improves diveregent but not convergent thinking.

To address our research goal, we ran two within-subjects studies. Study 1 compared two conditions with 11- to 12-year-old sixth-grade students: sit still—sitting still in a regular classroom chair with instructions to minimize movement; and freedom to move—sitting in a stool with a concave bottom which allowed rocking, with no instructions to minimize movement. Study 2 added a third condition with 12- to 13-year-old seventh-grade students: sit as usual—sitting in a regular classroom chair without any instructions to sit still, but rather, instructions to sit as they usually would if they were "paying attention" in class. Divergent thinking was measured with Guilford's alternate uses test. Divergent creativity was measured as the number of novel ideas, or candidate alternate usesthat no other student in the study sample generated. To test for selective effects we added an additional cognitive task to each study. For Study 1 we added a measure of memorization performance using the generation effect (see below); for Study 2, we added a measure of focused attention using a rapid matching task (see below). For each study, our primary hypotheses were students would have more novel ideas in the freedom to move condition than they did in either the sit still or the sit as usual conditions. Furthermore, the effect will be selective for the creativity task and there will be no condition differences on the memorization and focused attention measures.

Our exploratory hypotheses asked whether movement itself, regardless of condition, was correlated with novel ideas, or if movement suppression correlated with any changes in creativity seen between conditions. Each study included direct measures of student movement via accelerometers, which can be correlated against performances on the cognitive tasks. Importantly, children may respond differently to the instructions and seating. Some students will move even when told to sit still, and some students prefer to sit still even when encouraged to move. This would answer the question: Do kids that naturally move more, regardless of freedom to move or instruction to be still, have more novel ideas? An additional possibility is that kids who naturally move a lot have to do a lot of cognitive work to suppress their movement in conditions where they are told to be still. Here we took children's movement in their most suppressed condition as a proportion of their movement in the least suppressed condition—which we call "movement suppression." For example, say a child moved a lot in the freedom to move condition—and was wiggling practically off the chair. In the "sit still" condition, they may not have succeeded in being totally still but still suppressed a lot of movement compared to their natural freedom to move state. Similarly, a child may have moved very little in the freedom to move condition, and again not very much in the sit still or sit as usual condition. This would be a relatively small level of movement suppression. We explored whether movement suppression correlated with changes in creativity.

We add to the dynamic sitting literature in three ways with these two studies. First, for each of the two studies we examine selective effects of dynamic seating on cognition. In particular, we test whether dynamic seating improves creativity but does not affect memory acquisition or focused attention. This dissociative design helps to eliminate "halo effect" explanations (e.g., novelty just led children to try harder), mitigate concerns about negative side effects, and finally, help to indicate which cognitive tasks may specifically benefit from natural movement in dynamic sitting. Second, we incorporate an objective measure of physical movement using an accelerometer. By utilizing a within-student design, we control for baseline movement differences between children. Third, we utilize a wiggle stool rather than a stability ball. While both seating alternatives allow for natural movement, the wiggle stool can be also used to sit still without vertical bouncing if the child prefers (which the stability ball does not afford).

## Study 1: Freedom to Move Versus Sit Still

### Method

#### *Transparency and Openness*

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study, and we follow Journal Article Reporting Standards (Kazak, 2018). With attention to data privacy for the minors, we do not allow public data sharing. All the analysis code and research materials are available by emailing the corresponding author. Data were analyzed using R, Version 4.0.0 (R Core Team, 2020) and the package ggplot, Version 3.2.1 (Wickham, 2016). This study's design and its analysis were not preregistered. The sample size was constrained by the number of students in the science class available for participation. This study does not have precedent; thus we did not run a power analysis and instead emphasize reporting estimates along with 95% bootstrap intervals. Study 2 was used to demonstrate replication, which is a stronger evaluation of the persistence of detecting an effect than the theory-derived $p$ value Both protocols were approved by the Stanford Institutional Review Board.

#### *Participants*

Participants were 32 students (19 girls, 13 boys aged 11–12) drawn from two, sixth-grade science classes at a local, private school. In consultation with teachers, fidgeting was most prevalent in middle school and elementary ages, in contrast to high school age. With attention to data privacy, parental concerns, and collecting only the minimal data necessary for our hypotheses, no educational test scores, race/ethnicity, ADHD diagnosis, parental education, or parental income was recorded. Both parental consent and each student's assent were required for study participation. Four consented and assented students' responses were not used because of either misunderstanding the alternate use instructions or psychological discomfort with speaking aloud with unfamiliar adults.

#### *Procedure*

The study was a two condition (sit still vs. freedom to move) within-subjects design comparing the effects of freedom to move on creative thinking and a memory task. Condition assignment was counterbalanced by order.

A researcher first described the study design and student assent form in class. The students were told the study was investigating the "best conditions to help students think" (no hypotheses or conditions were shared). They were then taught what data privacy meant, with the following statements included: Students' participation would not be graded or count for class participation; no one in the class would see or know what their answers or results were, not even themselves; all students' results would ultimately be compared to their own selves, not each other; therefore, there was no peer competition. All students were then walked through the assent form and allowed to ask questions. They could sign yes or no to the assent form and were situated such that no other student in the class could see their response. Students were also given parent/guardian permission slips (also required for participation).

The list of students was alphabetized, and every other student was randomly assigned to a condition using a random number generator. For example, if the first student in the list was randomly assigned to the sit still condition first, then the next student on the list was automatically assigned to freedom to move condition. Measure forms were then counterbalanced so that each combination of measure forms (Alternate Use A or B, Memory A or B) was matched for each condition order (sit still first or freedom to move first). Therefore, order of test forms and condition were counterbalanced across participants; across both conditions, students saw each alternate use stimuli. Each student had at least 3 weeks between their conditions to minimize contamination.

Students were run through each condition in a pull-out from class with the experimenter. Pull-outs were timed with the science class curriculum to be during group activities or independent work to minimize missing classroom content. For each condition, the student participated in a separate room near the classroom with a desk and a chair facing a wall. The student was given a SenseWear accelerometer to wear on their arm to track their movement. The students were instructed how to think aloud using an example of how to make a peanut butter sandwich, shown the recorder, reminded there were no right or wrong answers, and that the experimenter would not interact with them during each thinking activity unless they had questions.

In the sit still condition, students were seated in a regular classroom chair and asked to place their hands and feet on colored discs to help them stay "as still as possible." In the freedom to move condition, students were seated in a "wiggle stool." A wiggle stool has a convex bottom that allows rocking. It was set to a height appropriate for middle school age. Children were told they could move freely as felt natural. Students first performed the alternate uses task. They then performed the memory task. Before returning to the classroom, students were reminded that to ensure every student gets a fair chance to find out how they think in different settings, they should not share the words they heard with other students.

After each student was run through both conditions and data were analyzed, the experimenters returned to the classroom to share the hypotheses and discuss the deidentified, aggregated results, explain the scientific method, and thank the students for participating in "real science research."

### *Measures*

**Creative Thinking (Alternate Uses).** We used Guilford's alternate uses task to measure divergent thinking (Guilford et al., 1960). Given 4 min, participants were asked to generate as many alternate uses as possible for common objects, such as button or tire. The alternate uses task has exhibited various forms of validity (Gibson et al., 2009; Harrington et al., 1983; Stimson, 1968), and it has been previously shown to be sensitive to movement conditions (Oppezzo & Schwartz, 2014). Each form of the alternate uses gives six unique objects, and the participant generates alternate uses for three objects at a time, for 4 min each. If students stopped early, they were encouraged to continue. We used two validated versions of the alternate uses so students were not generating uses for the same objects the second time they did the test.

**Memory (Generation Effect).** To dissociate the effects of freedom to move on creative thinking from other cognitive activities that do not show a previous relationship to movement, the "generation effect" was tested. The "generation effect" demonstrates that people are more likely to remember words they generate compared to words they read Slamecka and Graf (1978). Stimuli were 30, age-appropriate, user-tested (with sixth-graders from other schools) word pairs, broken into lists of synonyms, opposites, and rhymes. Half of the word pairs required the student to generate the second word by filling in blanks in the place of letters (e.g., "fast: r-p-d"), while the other half were completed (e.g., "fast:rapid"). The "generate" and "read" word pairs were shuffled within each list. A computer screen would flash each word pair for three seconds, and participants were instructed to subvocalize, or "say the words silently in (their) head." A brief distractor task (e.g., spell your last name backwards aloud) was added to eliminate the recency effect, where people hold the most recently heard words in memory. Participants were then asked to freely recall all the words. The generation effect predicts, independent of the list type, participants will recall more words from the "generate" pairs than from the "read" pairs. There were two versions of the memory word pair stimuli.

This memory phenomenon was included to help identify the selective effects of freedom to move on cognitive processes such as creative thinking. The finding that generation outperforms reading on memory is well-demonstrated. If this effect was not replicated evenly across conditions, then we could infer that the treatments were differentially influencing memory processes. Further, if the creativity measure showed a greater treatment effect than the memory measure, we could conclude there is a selective effect of treatment on creativity.

**Movement.** Movement in Study 1 was captured by a Sensewear triaxial accelerometer armband that students wore on their nondominant arm. The Sensewear's vector magnitude, or movement composite, for each session was the square root of the sum of the squares of the three acceleration axes. The standard deviation of this vector magnitude, rather than the mean, was then used to reflect the average variation in accelerated movement over the whole session. In low movement scenarios, the accelerometer signal is dominated by the Earth's gravity and the sensor is detecting changes in posture. Calibration offsets of accelerometers can also create an artificially high noise floor for mean measurements. For both of these reasons, the standard deviation will be a more sensitive measure for low movement. It is commonly used in nonwear detection (van Hees et al., 2011). The standard deviation of the vector magnitude was therefore used to reflect overall postural movement during the period of time they were seated in the chair doing the study measures. Going forward, the standard deviation of the vector magnitude will be referred to as "movement."

### *Data Preprocessing and Coding*

**Creative Thinking.** Artificial intelligence freeware is available online which automatically codes responses to the alternate uses test and gives each response a score on originality. We report the results of the Open Creativity Scoring with Artificial Intelligence system for analysis for Study 1 in the online supplemental materials (Organisciak et al., 2023). For reasons we describe in supplementary analysis, we chose the more cumbersome manual coding methods originally suggested by the Guilford coding manual and use these for our main outcome analyses.

Per Guilford's coding manual, responses passed through a series of three increasingly restrictive coding filters. The first pass was ideation, or the total number of generated uses for each set of three words. This could be considered a marker of fluency.

The second pass coded appropriate uses per Guilford's criteria: specific, different from the common use, and nonrepetitive. "Specific" means that the use had to be informative enough to be imaginable; "for fun" is too abstract to identify what the student had in mind as a use when suggested. Therefore, responses that were too vague were not counted as appropriate. "Different than the common use" means that the response was not related to what was stated as the usual use; using a shoe "for dancing" or "for running" are each using a shoe "as footwear," or on the foot for activity, and therefore not counted as different than the common use. "Nonrepetitive" means redundant ideas would only receive a single credit. For example, "using a pencil as a fidget tool" and "as a way to move your fingers during class" would only be counted as one idea. This criterion also ensured more loquacious students did not get extra counts for saying the same idea more than once. Because of the nonrepetitive criterion, a student's appropriate number of responses could be considered a marker of creative flexibility, or the number of different categories of ideas.

Guilford's original criteria for an idea to be considered appropriate was relaxed for this study to include kid-appropriate creativity. For example, "smashing open a brick to see what's inside" or "throwing it to the ground to see if it sticks" would not be counted as appropriate for adults by Guilford's original criteria, because it does not indicate the purpose, therefore was not a "use." For our student age group, we accepted ideas with less definitive purposes as age-appropriate. For a child, seeing whether a pencil sticks in the ground is the purpose, even if not an adult-accepted "use" of a pencil. The boundaries of appropriate codes were determined by two independent coders before the data were coded. A primary coder scored all responses, and a secondary coder scored a random 10% subset, with a Cohen's kappa of .861, $p < .001$.

The final coding pass defined creativity as corpus novelty: an appropriate response that was unique to the entire corpus of responses. If two or more students gave the same use for a response, it did not count as novel for either student. This is a stringent definition of creativity, requiring that no other student said the idea. Guilford does not list specific novelty criteria. Some approaches to measuring novelty assign weights to responses depending on the overall prevalence within the corpus (e.g., 5% vs. 1%; Bayliss, 2016). With thousands of responses, the simplest code technique was to reserve the code of "novel" only for truly original responses within the sample (see Oppezzo & Schwartz, 2014).

Given that novelty depended on the entire corpus, the criteria for novelty were separately coded within 10% subset to check interrater reliability. The Cohen's kappa for novelty coding was .820, $p < .001$.

To ensure that our measure of novelty was not confounded by fluency, or number of ideas, we defined and calculated creativity ratio: the number of novel ideas divided by the ideation (total number of ideas). We used this to detect whether freedom to move would increase novel idea generation independent of increased loquaciousness.

**Memory.** We coded correctly remembered words. Intrusions, or responses that were not stimuli words, were rare and not counted. Words that came from the first and last two pairs of words in the memorization list were excluded to remove any effects of recency or primacy. We compared the total number of recalled words from the generate pairs versus the read pairs.

**Movement Data.** When possible, the alternate uses task was not initiated until the accelerometer had accrued the 3–5 min of body temperature to initiate data recording. To avoid excessive time out of class, the experiment had to be initiated sometimes before the accelerometer had begun recording. For this reason, we did not check for a time correspondence between movement and ideas spoken. Additionally, because the accelerometer only shut off after removal and the removal of the band from the arm involved poststudy session movement, the accelerometer data were cleaned by removing the final 2,160 rows ($\sim$1 min of recording) for the analysis.

We make an assumption that the student's movement in the freedom to move condition is their baseline, unencumbered degree of fidgetiness. Therefore, to determine movement suppression, each student's sit still movement was divided by their freedom to move movement. A smaller ratio would indicate a higher degree of suppression, and a larger ratio would indicate a lower degree of suppression.

## *Data Analysis*

Given that this is a relatively new effect being evaluated, we make limited use of the hypothesis confirmatory framework. In practice, we use tests to evaluate the primary hypotheses in both studies. For all other quantities of interest, we emphasize estimation of an effect and reporting of the amount of uncertainty for those estimates through the use of bootstrap intervals. This framework, with an emphasis on estimates and uncertainty rather than confirmation, is because of fact this is a relatively unexplored phenomenon in the literature. In addition, the two study setup was designed for replication of effects, an alternative form of hypothesis confirmation.

**Sensitivity Analyses: Test Form and Order.**

***Hypothesis.*** Neither test form nor order would significantly affect the number of novel ideas. We ran a generalized linear model, with a negative binomial link function, to test the effects of test form (A vs. B) and order (freedom to move first vs. second) on number of novel ideas generated and appropriate ideas generated. Fixed effects were used for form and order.

**Primary Analysis and Hypotheses.**

***Hypothesis 1 (H1).*** Students would have more novel ideas in the freedom to move condition compared to the sit still condition. We used a Wilcoxon ranked sum test to evaluate the effect of condition (still vs. freedom to move) on the number of novel ideas generated. We used generalized linear mixed models (GLMM) to estimate the effect of condition on novel ideas generated and the creativity ratio, number of novel ideas/total ideation. The number of novel ideas is the primary outcome of interest, with the secondary outcome being the creativity ratio (used for contrast, assessing if the mechanism of increase in primary outcome was through more ideas being expressed). We also used GLMMs to assess ideation and appropriate ideas by condition; these are reported in the online supplemental materials.

***Hypothesis 2 (H2).*** We did not expect an effect of freedom to move on the generation effect for memory. On average, students would remember more "generate" words than "read" words (the "generation effect") regardless of condition. To test this, we first ran a GLM to test the Effect of Condition (Sit Still vs. Freedom to Move) × Memory Pair (Read vs. Generate) on the number of words recalled. We then used a noninferiority testing framework to quantify what effect sizes of condition on the "generation effect" we could rule out.

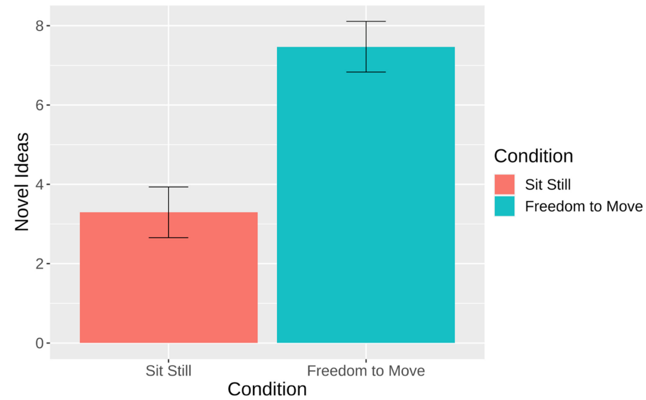
**Exploratory Analyses.**

***Exploratory 1.*** Did students' movement correlate with novel ideas within condition? We checked for a correlation between vector magnitude of movement with novel ideas within condition. We do this as a peek at mechanism, and to ensure that condition is driving effects, not innate traits. If variation in novel ideas was well predicted by movement, we might think that wigglier kids were the ones producing the observed effects instead of the intervention condition which provided freedom to move as was natural.

***Exploratory 2.*** Did students' movement suppression correlate with the effect of freedom to move on their creative thinking? We checked for a correlation between movement suppression with the difference of students' novel ideas between conditions.

**Figure 1**

*Average Novel Ideas × Condition*




*Note.* Error bars reflect standard errors. See the online article for the color version of this figure.

## Results and Discussion

### *Sensitivity Analysis: Test Form and Order*

Our randomization scheme ensured balance on the ordering of conditions and test materials. In sensitivity tests, neither the test form nor order of condition exhibited effects on novel ideas (all $ps > .05$), nor appropriate ideas (all $ps > .05$). Consequently, test form and condition order were not included as factors in analyses.

### *Primary Analyses*

**H1.** We detected a significant effect of condition (sit still vs. freedom to move) on novel responses (Wilcoxon signed rank $V = 496.5$, $p < .0001$; estimate of coefficient for condition from a GLMM, negative binomial link: −.819, with a 95% bootstrap interval [−1.12, −0.54]). The coefficients of a negative binomial can be interpreted as odds ratios, after exponentiation; in this case, the coefficient of −.819 can be interpreted as 44.1% decrease of novel ideas in the sit still condition. The same held true for creativity ratio, with a significant effect of condition (−.129 estimate with a 95% bootstrap interval [−0.181, −0.076], difference in means between conditions as estimated by a linear mixed model).

The freedom to move condition exhibited more novel ideas overall along with a greater density of creative ideas per total idea generation (therefore the increase in novel ideas was not only explained by having more total ideas). Figure 1 shows the means and standard errors by condition of novel ideas. Figure 2 shows that roughly 80% of the students were more creative in the freedom to move condition. Exactly two students generated exactly zero novel ideas under both conditions (therefore there is one line representing these two students in Figure 2).

**H2.** A repeated measures analysis of variance (ANOVA) of Condition (Sit Still vs. Freedom to Move) × Memory Pair (Read vs. Generate) showed a significant effect of memory pair, $F(1, 33) = 20.45$, $p < .001$ (i.e., a significant generation effect), which replicates prior findings. Importantly, there was no significant effect of condition, $F(1, 33) = 0.02$ on overall memory, $p = .89$, and no significant interaction of condition by the difference between generate and read recall, $F(1, 33) = 1.58$, $p = .22$. The conditions did not impact memorization processes. Figure 3 shows the means by condition and memory pair.

A GLMM with a negative binomial link was used to estimate effects of condition (sit still vs. freedom to move), memory pair (read vs. generate), and their interaction using fixed effects, and a random effect was used to account for within-subject repetition. The coefficient for the interaction term had a 95% bootstrap interval [−0.185, 0.771] with a point estimate of .281, which notably contains the null value of 0 which replicates prior findings. The coefficient for the condition term had a 95% bootstrap interval [−0.346, 0.137] and a point estimate of −.116, which notably contains 0 which is consistent with the hypothesis that no effect of movement condition on recall. However, the coefficient for memory pair (read vs. generate) had a 95% coefficient of −1.036 to −.395 with a point estimate of −.671. Importantly, and consistent with prior research, note that the 95% interval does not contain zero and indicates a lower recall ability when participants read rather than generated.

### *Exploratory Analyses*

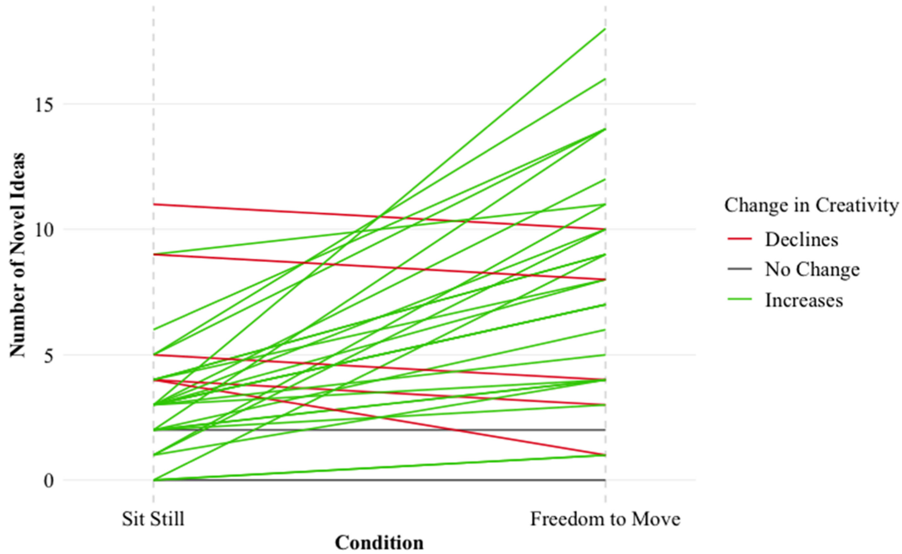
**Exploratory 1.** Movement did not correlate with appropriate or novel ideas within condition. Movement in the sit still condition did not correlate with number of acceptable ideas, $r = .042$, $p = .824$, nor novel ideas, $r = .240$, $p = .193$. Movement in the freedom to move condition did not correlate with number of acceptable ideas, $r = -.032$, $p = .862$, nor novel ideas, $r = .078$, $p = .670$. Based on this result, it does not appear that "wiggly kids" are any more or less creative than others.

**Exploratory 2.** Movement suppression was not significantly correlated with the effect of freedom to move on novel ideas (subtraction of freedom to move novel ideas from sit still novel ideas), $r = .07$, $p = .69$.

### *Study 1 Discussion*

When given the physical (wiggle stool) and psychological (no instructions to suppress movement) freedom to move, students on average had more novel ideas than they did when given

**Figure 2**
*Individual Novel Ideas × Condition*

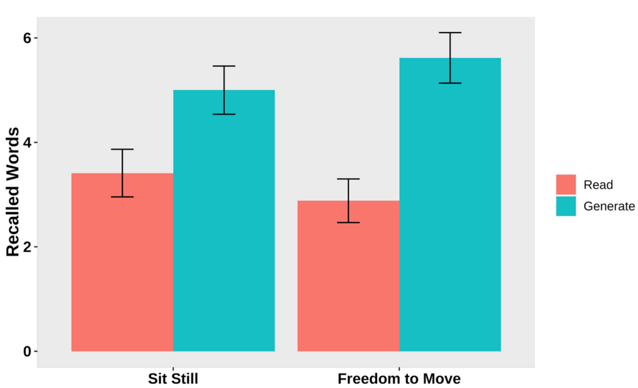



*Note.* Green (light gray) lines indicate a relative increase from the lower to higher movement condition. Red (dark gray) lines indicate a relative decrease in novel ideas from the lower to higher movement condition. Gray line indicates no change. See the online article for the color version of this figure.



physical (hard bottom chair) and psychological (told to suppress their movement) constraints on movement. This effect was not because of being more loquacious or having a larger number of ideas overall, as the freedom to move effect also remained for the ratio of novel ideas to total ideas generated. The results are consistent with the effect of freedom to move being selective for our measure of creative thinking, as we did not find a statistically significant effect of condition on memory performance nor the generation effect, where more words with generation are recalled than words without generation. Finally, it appears that individual differences in amount of movement do not correlate with creative output.

**Figure 3**
*Number of Correctly Recalled Words by Condition and Memory List (Read or Generate)*




*Note.* Error bars represent standard errors. See the online article for the color version of this figure.

## Study 2: Freedom to Move Versus Sit as Usual Versus Sit Still

A Study 1 found that freedom to move led to an increased number of novel ideas for most students relative to sitting still. However, one key limitation of this study was we could not test whether it was the freedom to move that helped divergent thinking, or the suppression of movement that hurt divergent thinking. Although the movement suppression analysis suggested suppression did not drive a decrease in creativity, it was a correlational analysis. Therefore, in Study 2, we added a third condition, "sit as usual," with a regular chair to reflect a condition with instruction to sit as if they were in class paying attention. The regular chair impeded the physical freedom to move, while the instructions did not impose a psychological restriction of movement. Conceptually, the sit as usual condition sets up a chance to identify if the freedom to move helps, or if the suppression in the sit still condition hurts. If each of the three conditions is significantly different from each other, then this implies it may be a little bit of both.

A second limitation of Study 1 was that the SenseWear accelerometer was worn on the arm. As such, it was relatively insensitive to lower body movement. In Study 2, we used a more sensitive accelerometer and added it to the hip. Finally, while not a limitation, it would be valuable to measure whether movement interferes with another cognitive activity important to the classroom, namely focused attention.

In sum, Study 2 used the same methods as for Study 1 with the following design changes: (a) Added a third condition, "sit as usual," to reflect conditions of classroom standard norms; (b) recruited seventh-grade students, instead of sixth-graders; (c) replaced the generation effect phenomenon with focused attention as the comparator cognitive task; and (d) used a new accelerometer (GENEActiv) and movement measure shown to be more sensitive to microfidgeting movements.

Given many classroom norms do not explicitly encourage freedom to move, and some view movement as problematic, we expected the "sit as usual" condition to have an implied psychological constraint on the freedom to move. Therefore, while we expected students to vary in their movement in response to the instruction to "sit as if you are paying attention in the classroom," we expected that the overall movement level will be closer to their movement than in the "sit still" condition, which explicitly asked students to stay still and used discs to place their hands and feet. We therefore hypothesized that students would have more novel ideas in the freedom to move condition compared to the sit as usual and sit still conditions, which we did not expect to be appreciably different from each other. Further, we expected that this effect would be selective only for creative thinking, not for focused attention.

## Method

### Participants

Participants were 43 students (27 girls, 16 boys aged 12–13) drawn from two, seventh-grade science classes. Both parental consent and student assent were required for study participation. Unfortunately, because of the COVID-19 pandemic and the consequential school closures, each child only received two conditions at most. No child completed their third condition. See data analysis section for related analysis method modifications.

### Procedure

A within-subject research design compared the differences between sit still, sit as usual, and freedom to move condition on creative thinking and a focused attention task. Condition assignment was counterbalanced by order.

The methods were similar to Study 1 with the class description of the study, assenting and consenting process, randomization, and pull-out timing and location. The student was given two GENEActiv triaxial accelerometers, with one placed on the student's hip using a belt, and the other placed on the student's nondominate upper arm using an arm strap. The hip belt proved to be sufficient, therefore we did not use the upper arm data.

In the sit still condition, students were seated in a regular classroom chair, and asked to place their hands and feet on flat discs to encourage them to stay "as still as possible." In the sit as usual condition, students were seated in a regular classroom chair and were told to sit as though they normally would in a classroom setting. Finally, in the freedom to move condition, the regular classroom chair was swapped with a wiggle stool (from Study 1) and the students were told they could move freely as felt natural. Students were asked to perform two tasks: creative brainstorming and focused attention. There were three different versions of the creative thinking and focused attention tasks; order of test versions and condition were fully crossed for all participants. At least three weeks separated each student's pull-out to remove risk of contamination.

### Measures

**Creative Thinking.** The same task, Guilford's Alternate Uses, was used in Study 2. However, because the alternate uses only provided two test forms, we created a third form to allow for three within-subject conditions in the design. We first divided the original two forms (two forms with six objects each form) into three forms with four objects each form, with the goal of equalizing the objects' potential uses across forms. For example, one may be able to generate many more ideas for a raw material such as a bedsheet compared to a more intricate object such as a watch. We did not want any list to include all bedsheet-type objects and another all watch-type objects. We used Study 1's data to assign a weight of average appropriate uses to each object, and then distributed the objects across three test forms so the sum total weight was equivalent across forms. We then user-tested six more objects with both sixth- and seventh-grade students to assign average appropriate use weights to each new object. We finally divided these six new objects across the three test forms (two objects each) so that the total weight was equivalent across forms.

**Focused Attention.** To evaluate focused attention, students were asked to match numbers to letters given a key. For example, they would view a table on the computer where the top row had a list of nine random letters, and the next row had a list of nine numbers (this table is the code key). For example, in the first position, a 1 was under Y, and in the second position, 2 was under M. Below, there is a second table that lists a series of 15 letters. Their task is to orally name the associated numbers, using the code key table above. After completing the 15 letters, they then moved to a new key and list of letters. This continued for 90 s. Students were told to work as quickly as possible without making errors.

As with the generation phenomenon in Study 1, this focused attention measure was included to help identify the selective effects of freedom to move on cognitive processes such as creative thinking. If the creativity measure showed a greater treatment effect than the focused attention measure, we could conclude there is a selective effect of condition on creativity.

**Movement.** To capture students' movement, we utilized the GENEActiv triaxial accelerometers, with one placed on the student's hip and the other placed on the student's nondominate upper arm. The accelerometers were configured to record at 100 Hz. Two major measurements were taken from the accelerometer data: mean gravity-subtracted acceleration from the three axes and a ratio of the 2–10 Hz mean acceleration to the mean gravity-subtracted acceleration. The frequency filter aims to isolate finer, repetitive movements, and a frequency window of 2–10 Hz was determined through the combination of examining the raw data and the existing literature on Parkinson's tremors (Gauthier-Lafreniere et al., 2022). The hip ratio of 2–10 Hz signal to the mean acceleration was chosen by the team as the best measure to capture student fidgeting and micromovements. We continue to refer to this as "movement" in Study 2 for simplicity, while acknowledging the measurements are not identical.

### Data Preprocessing and Coding

**Creative Thinking.** Data were coded in Study 2 using the same methods as Study 1. All responses were anonymized and condition-blinded. Appropriate ideas were coded by two independent coders for six rounds of 100 randomly selected responses each round; disagreements were discussed with codebook updates as necessary in between each round. Interrater reliability was measured using Cohen's kappa, with index agreements of: .51, .55, .58, .49, .69, and .88. Once the .88 agreement was reached, a single coder coded the remainder of the data set for appropriate responses. For novel ideas, no other student could have said the idea to get credit. Both coders ultimately independently coded the whole corpus of responses because the novelty code depends on the entire corpus. For the novel responses, seven rounds of ∼100 responses per round novel coding were conducted with interrater reliability as follows: .65, .74, .68, .78, .69, .79, and .77. Ultimately, when the two coders disagreed for the novel responses, a third trained party was brought in to discuss and collectively determine the outcome. Condition was blinded throughout the entire coding process.

**Focused Attention Scores.** Focused attention scores were the total number of correct answers produced in 90 s.

**Movement.** The GeneActiv accelerometer did not need to acclimate to body temperature like the SenseWear; however, the first and last minutes of accelerometer data were discarded to ensure that no signals from fitting or removing the accelerometer from the student were included in the analysis. For each session, the hip ratio of 2–10 Hz was calculated as a marker of overall movement.

Movement suppression was calculated similarly to Study 1 but using the movement readings from the hip accelerometer as described above. We make an assumption that the student's movement in the freedom to move condition is their baseline, unencumbered degree of fidgetiness. Therefore, to determine movement suppression, each student's sit still movement was divided by their freedom to move movement. A smaller ratio would indicate a higher degree of suppression, and a larger ratio would indicate a lower degree of suppression.

### *Data Analyses*

For each outcome, we estimated the effect of condition by (a) fitting a generalized mixed effects model for the outcome (e.g., with a negative binomial link for count data) with a fixed effect for condition and a random intercept for the student and then (b) using 500 bootstrap replicates of the model to generate 95% intervals of the estimated coefficients. Generalized linear mixed effects models were fit with the lme4 package in R (Bates et al., 2015). For the sensitivity analysis of test form and order, we used an $F$ test of a linear model which was evaluated using the ANOVA function from the lmerTest package in R (Kuznetsova et al., 2017) and Satterthwaite's method for calculating the denominator degrees of freedom and $F$ statistics (Satterthwaite, 1946).

**Sensitivity Analyses: Test Form and Order.**

***Hypothesis.*** Neither test form nor order would significantly affect the number of novel ideas. We used the linear mixed effects described above with test form and order as the factors to test the effects of test form and order on number of novel ideas generated and appropriate ideas generated.

**Primary Hypotheses.**

***Hypothesis 1.*** Students would have more novel ideas in the freedom to move condition compared to the sit as usual and sit still conditions, which would not be appreciably different from each other. We used the mixed effects model described above on the number of novel ideas generated and the novelty ratio (novel ideas divided by total ideation).

***Hypothesis 2.*** We expected the effect of freedom to move to be selective for creative thinking, and therefore we did not expect an effect on focused attention. To test this, we first used the mixed effects model described above on the focused attention score. We then use a noninferiority testing framework to quantify what effects sizes of condition on focused attention we can rule out.

**Exploratory Analyses.**

***Exploratory 1.*** Did students' movement correlate with novel ideas within condition? We used a correlation between movement with novel ideas within each condition.

***Exploratory 2.*** Did students' movement suppression correlate with the effect of freedom to move on their creative thinking? We used a correlation between movement suppression with the difference of students' novel ideas between conditions.

## Results and Discussion

### *Sensitivity Analyses: Test Form and Order*

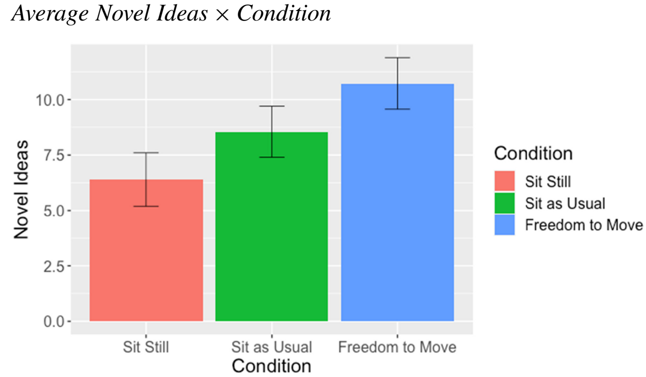
Neither the test form nor order of condition exhibited effects on novel ideas (all $p > .05$) nor appropriate ideas (all $p > .05$); therefore, they were not included as factors in later analyses.

### *Primary Analysis*

**H1.** The linear mixed effects ANOVA showed a significant effect of condition on novel ideals within subject, $F(2, 39.44) = 7.38$, $p = .002$. A priori pairwise comparisons using sit as usual as the reference condition were *ns* (sit still vs. sit as usual, $p = .05$, and freedom to move vs. sit as usual, $p = .06$). The same held true for creativity ratio, with a significant effect of condition overall, $F(2, 55.40) = 3.44$, $p = .039$, but no significant differences in the pairwise comparisons. Figure 4 shows the mean novel ideas by condition. Figure 5 shows each individual students' scores across their pair of conditions. For those students who completed the sit still and freedom to move conditions (middle panel), the percentage exhibiting more creativity in the freedom to move condition (81.8%) closely replicates the findings from Study 1.

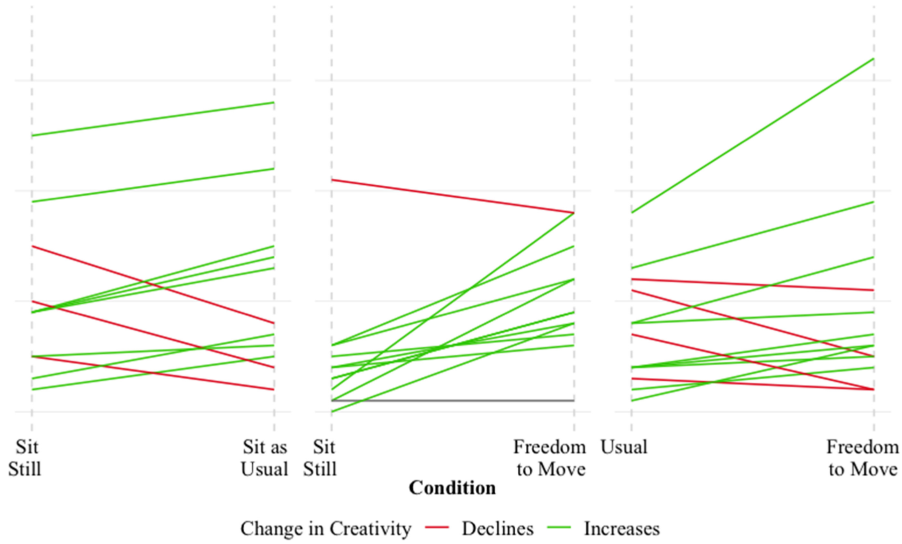
With still as the referent condition, the generalized linear mixed effects model of novel ideas generated estimated coefficients of .246 (95% bootstrap interval [0.029, 0.912]) to switch to the usual condition, and .555 (95% bootstrap interval [0.158, 0.963]) to switch to the freedom to move condition. Similarly for creativity ratio, a linear mixed effects model estimated coefficients of .106 (95% bootstrap interval [0.010, 0.231]) to switch to the usual condition, and

**Figure 4**
*Average Novel Ideas × Condition*




*Note.* Error bars indicate standard errors of the means. See the online article for the color version of this figure.

**Figure 5**
*Individual Novel Ideas × Condition*




*Note.* Green (light gray) lines indicate a relative increase from the lower to higher movement condition. Red (dark gray) qtplines indicate a relative decrease in novel ideas from the lower to higher movement condition. Gray line indicates no change. See the online article for the color version of this figure.

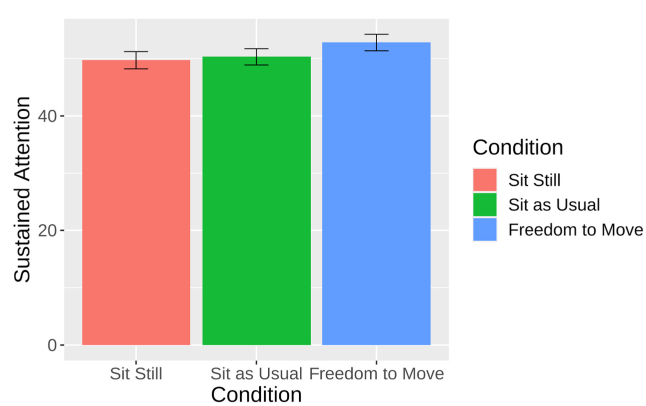
.107 (95% bootstrap interval [0.027, 0.240]) to switch to the freedom to move condition. For both outcomes, we see that the 95% bootstrap intervals do not contain the null coefficient of 0—they all estimate an increase when switching away from the still condition, and with point estimates being higher in the freedom to move condition when compared to the usual. Figure 4 shows the mean novel ideas by condition. Figure 5 shows each individual students' scores across their pair of conditions (each line represents one student's data). For those students who completed the sit still and freedom to move conditions (middle panel), the percentage exhibiting more creativity in the freedom to move condition (81.8%) closely replicates the findings from Study 1.

**H2.** The linear mixed effects model showed no significant effect of condition on total focused attention within subject, $F(2, 42.86) = 2.17$, $p = .13$. Figure 6 shows the means of the focused attention score across conditions. Using an equivalence testing framework, we can reject the possibility of large effects (Cohen's $d$ of 0.7, or about 5.6 points) of condition on focused attention (Lorah 2018). Still condition 95% confidence interval (CI): [−3.8, 2.6], equivalence $p = .001$; freedom to move condition 95% CI: [−0.0959, 5.6], equivalence $p = .023$. This means that the effect of condition on focused attention is quite small, at least relative to the creativity effect, although with a larger sample size the effects on attention might reach significance. To rule out smaller effects of condition on focused attention, we would need to have all participants complete each condition, which was impracticable.

### *Exploratory Analyses*

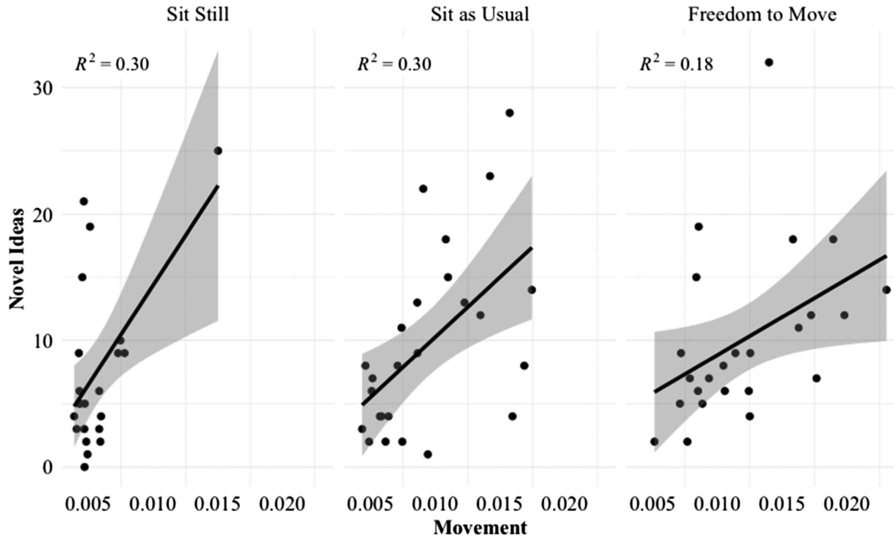
**Exploratory 1.** Unlike Study 1, movement did significantly correlate with novel ideas within condition. Movement in the sit still condition correlated with novel ideas, $r = .55$, $p = .0078$. Movement in the sit as usual condition correlated with novel ideas, $r = .55$, $p = .0045$. Movement in the freedom to move condition correlated with novel ideas, $r = .424$, $p = .039$. This means across students, within any given condition, the amount the student moved moderately correlated with their number of novel ideas. Figure 7 shows the movement by novel ideas within each condition. Figure 7 also allows for the reader to assess if the randomized condition correlated with the intended exposure (i.e., having the freedom to move led to relatively more movement and a higher max of movement along the $x$-axis while being told to sit still led to relatively less movement and a more truncated range of movement along the $x$-axis). While there was variability of movement within each condition, across conditions comparison shows that more students

**Figure 6**
*Focused Attention*




*Note.* Error bars indicate the standard errors of the means. See the online article for the color version of this figure.

**Figure 7**
*Movement × Novel Ideas Within Condition*




*Note.* Movement is the *x* axis, number of novel ideas on the *y* axis, with best fit lines and 95% confidence intervals in gray. Each student has a data point in two of the three conditions.



moved more in the sit as usual and freedom to move conditions compared to the sit still. One possible explanation for the significant correlations in this study versus the null effects of Study 1 has to do with the placement of the accelerometer. In Study 1, it was on their arm, whereas in Study 2, we used the accelerometer data from their hip. Additionally, using the different device and more sensitive measure of movement may also explain part of this difference.

Of note, further exploration showed no significant correlation within condition between movements made during the focused attention task and focused attention scores.

**Exploratory 2.** Movement suppression (highest movement condition movement—lowest movement condition movement) was not significantly correlated with change in novel ideas (highest movement condition novel ideas—lowest movement condition novel ideas). Students who were in both still and freedom to move conditions, $r = .40$, $p = .078$; students who were in sit still and sit as usual, $r = .27$, $p = .29$; students who were in both sit as usual and freedom to move, $r = .17$, $p = .40$.

### *Study 2 Discussion*

Study 2 replicated the primary outcomes from Study 1 in seventh-grade students, demonstrating that roughly 80% of students generated more novel ideas in the freedom to move condition compared to themselves in the sit still condition. There was an overall effect of condition showing an apparent linear trend with being in the sit still as the least creative and being in the freedom to move as the most creative. Given this trend, it implies that there is not only a benefit from having a physical freedom to move, but also a potential harm to suppressing movement. The results were largely the same for creativity ratio, which means that the increase in novel ideas was not because of simply being more loquacious. Statistical power was less than expected since the experiment was cut short by the COVID-19 school shutdown, meaning that only 2/3 of the planned data collection was feasible. Finally, like Study 1, the effect of freedom to move was selective to creative thinking and did not appreciably affect our measure of focused attention.

Unlike Study 1, in an exploratory analysis, we found a possible linear correlation between movement and novel ideas in Study 2. In Study 2, it appears that students who moved more produced more creative ideas. This finding could be because of our more sensitive measure of movement. In particular, in Study 2, the measurement was taken at the hip, which means it could detect foot tapping or chair swiveling. Thus, one possible explanation is that movement of the legs or body, in particular, is responsible for the creativity effect, which was unmeasured in Study 1. Future studies will need to examine this and other possible explanations for this inconsistency between Study 1 and Study 2.

## General Discussion

Taken together, these studies suggest that giving sixth- and seventh-grade (11- to 13-year-olds) students both physical opportunities to move through dynamic seating, and psychological freedom to move by not instructing them to suppress their movement, could help students maximize one kind of creative thinking: generating new ideas. The effect was indicated in both studies, both age groups, and independent of the student's overall talkativeness or tendency to move. We did not find evidence that this type of dynamic seating or freedom to move would negatively affect other cognitive tasks such as memory or focused attention, a potential worry for teachers.

### Implications for the Classroom

The findings that dynamic seating does not hurt performance on various cognitive tasks is consistent with other work noting that while stability ball and unstable chairs may decrease perceived productivity in reading comprehension, there was no difference in actual performance compared to a stable chair (Doroff et al., 2019). Dynamic seating therefore may be used to help boost creative idea generation in certain classroom activities, and remain as the standard seating choice, with no current evidence to suggest this dynamic seating would affect short tests of memory or attention. Providing dynamic seating also shows school and teachers' acceptance of a norm where students can feel "free" to move their body in the way that feels natural for them, without worrying or wasting cognitive effort on suppressing their movement tendencies. This is a form of seating that also works with different learners, in line with Matin Sadr et al.'s (2017) work showing increased on-task behavior for those with autism spectrum disorder. Some classrooms are offering standing desks, which is another good way to allow for more movement. However, of note, prolonged standing is not harmless, comes with postural- and circulation-related risks, and lends to more leaning and shifting, rather than natural rocking, tapping, or fidgeting like the dynamic sitting affords. Figure 5 reveals the suggestion of a suppression effect when asking students to sit still. Roughly 73% of the students were more creative in the Sit as Usual condition compared to their performance in the Sit Still condition. Additionally, 82% of the students were more creative in the Freedom to Move condition than the Sit Still condition, which is a greater percentage of increase than the 70% gain from Freedom to Move compared to Sit as Usual. If these patterns hold up in subsequent research, it raises the question of whether the negative creativity effects of asking students to stay still rests on the same cognitive mechanisms that drive the positive effects of the Freedom to Move condition. There are models where it could be separate processes, for example, the cognitive demands of surpressing movement may be a distraction, whereas the natural movement of fidgeting may relax the filtering of ideas

## Implications for Physical Activity Research

In the public health domain, most children and adults are not meeting the physical activity guidelines for health (Office of Disease Prevention and Health Promotion, n.d.). Even if they were, sedentary physiology findings show that even single bouts of exercise cannot always erase the cardiovascular risks of prolonged sitting (Andersen et al., 2007; Baker et al., 2018; Chester et al., 2002; Graf et al., 2015; Tüchsen et al., 2000; Waters & Dick, 2015). Therefore, many physical activity studies are looking for ways to interleave movement throughout sitting periods (Anderson et al., 2021; Bailey et al., 2019; Bedard et al., 2019). As noted in the introduction, the work on physical activity and movement in the classroom varies in physical activity type and intensity.

Dynamic seating involves unstructured, natural, micromovements, not exercise, or structured physical activity. Snarr et al. (2019) notes only a small increase in heart rate and energy expenditure in movement on a similar unstable seat compared to either a regular chair or stability ball, which did not differ from each other. However, it may be the case that dynamic seating allows for enough lower body movement to combat some of the physiological effects of prolonged sitting. This study showed significant microlevel movement differences between the still and wiggle chair conditions.

Notably, some work has found an association between mind wandering (or off-topic thinking) and self-reported fidgeting (Carriere et al., 2013). Our findings differ here as the creative divergent thinking task required intentional and task-related thought. The creative ideas were within the constraints of the task, not generated as a result of thinking outside the task as in mind-wandering.

## Implications for Creativity Research

This work is in line with prior findings showing that walking differentially improved creative, but not focused thinking, in most adults (Oppezzo & Schwartz, 2014). However, walking outside during certain activities is not always feasible, and treadmill desks are expensive, often noisy, and take up space. Dynamic seating may have a smaller effect on creative thinking, but is more practical for enhancing divergent thinking in a classroom setting.

## Limitations and Future Directions

One unfortunate limitation of this study was the premature conclusion of Study 2. If each student completed all three conditions, the study would have had more power to detect effects of condition. However, the results with the mixed effect models were enough in the right direction to suggest that a replication of this study design might find significant differences.

Another limitation is the lack of ecological validity. To minimize contagion and distraction, this study was done in individual pull-outs rather than part of a larger classroom setting. Running the study in the classroom setting could test the robustness of this effect in the group setting. It can also test teachers' perceptions and concerns of "movement contagion" as being a sign of distraction and disarray. Such a study might also track distraction from other students' movement by comparing the focused attention of students seated next to "high movers" in either still or freedom to move conditions. This would be a good design of whether a neighbor's movement affects one's focused attention, as this study only showed one's own movement did not prove distracting.

Finally, we did not collect demographics, cultural differences, or attitudes toward ideal classroom behavior. Future research can explore whether other variables may influence any student's individual perceptions of freedom to move.

We did not compare fidgeting levels between the divergent thinking task and the focused attention task because the latter required focusing on a computer screen, which would naturally constrain the amount of gross movement. Future studies should include an audio-only metric of attention to evaluate how a student's natural level of fidgeting varies across types of thinking tasks.

Future research should also include timestamps for each idea and do a time-series analysis of the idea generation and accelerometer data. This may help dissociate the difference between freedom to move improving novel ideas from actual, in-the-moment or concomitant movement correlating with each novel idea generation.

We did not test the wiggle chair without the freedom to move instructions, nor the freedom to move instructions without the wiggle chair. Our primary goal was to determine whether fidgeting behavior can contribute to creativity without interfering with other cognitive functions. Future research should determine whether freedom to move instructions would boost creativity without the wiggle chair. Reciprocally, it may be too cognitively demanding for students to stay still in a wiggle chair.

## Conclusion

Modern classrooms are drastically changing from traditional schoolhouses with hard-backed seats, hands-folded, facing the teacher at the front. Innovative and active learning tasks and environments are being created to optimize health and education. This set of studies may contribute to the thoughtful redesign of future classrooms to set up optimal learning environments. We hope it is a step, or a wiggle, in the right direction. What also remains to be tested is—how distracting is it for teachers to have students wiggling about in their stools?

## References


Alderman, B. L., Olson, R. L., & Mattina, D. M. (2014). Cognitive function during low-intensity walking: A test of the treadmill workstation. *Journal of Physical Activity & Health*, *11*(4), 752–758. https://doi.org/10.1123/jpah.2012-0097

Andersen, J. H., Haahr, J. P., & Frost, P. (2007). Risk factors for more severe regional musculoskeletal symptoms: A two-year prospective study of a general working population. *Arthritis and Rheumatism*, *56*(4), 1355–1364. https://doi.org/10.1002/art.22513

Anderson, J., Williams, A. E., & Nester, C. (2021). Musculoskeletal disorders, foot health and footwear choice in occupations involving prolonged standing. *International Journal of Industrial Ergonomics*, *81*, Article 103079. https://doi.org/10.1016/j.ergon.2020.103079

Bailey, D. P., Hewson, D. J., Champion, R. B., & Sayegh, S. M. (2019). Sitting time and risk of cardiovascular disease and diabetes: A systematic review and meta-analysis. *American Journal of Preventive Medicine*, *57*(3), 408–416. https://doi.org/10.1016/j.amepre.2019.04.015

Baker, R., Coenen, P., Howie, E., Lee, J., Williamson, A., & Straker, L. (2018). A detailed description of the short-term musculoskeletal and cognitive effects of prolonged standing for office computer work. *Ergonomics*, *61*(7), 877–890. https://doi.org/10.1080/00140139.2017.1420825

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Bayliss, A. (2016). *Testing creativity: Three tests for assessing creativity*. 1st Maker Space. https://arlonbayliss.com/wp-content/uploads/2016/11/3.Creativity-Tests.pdf

Bedard, C., John, L. S., Bremer, E., Graham, J. D., & Cairney, J. (2019). A systematic review and meta-analysis on the effects of physically active classrooms on educational and enjoyment outcomes in school age children. *PLOS ONE*, *14*(6), Article e0218633. https://doi.org/10.1371/journal.pone.0218633

Best, J. R. (2010). Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise. *Developmental Review*, *30*(4), 331–351. https://doi.org/10.1016/j.dr.2010.08.001

Bowden, E. M., & Jung-Beeman, M. (2003). Normative data for 144 compound remote associate problems. *Behavior Research Methods, Instruments, & Computers*, *35*(4), 634–639. https://doi.org/10.3758/BF03195543

Campbell, D. W., Eaton, W. O., & McKeen, N. A. (2002). Motor activity level and behavioural control in young children. *International Journal of Behavioral Development*, *26*(4), 289–296. https://doi.org/10.1080/01650250143000166

Carriere, J. S., Seli, P., & Smilek, D. (2013). Wandering in both mind and body: Individual differences in mind wandering and inattention predict fidgeting. *Canadian Journal of Experimental Psychology*, *67*(1), 19–31. https://doi.org/10.1037/a0031438

Carson, S., Shih, M., & Langer, E. (2001). Sit still and pay attention? *Journal of Adult Development*, *8*(3), 183–188. https://doi.org/10.1023/A:1009594324594

Chester, M. R., Rys, M. J., & Konz, S. A. (2002). Leg swelling, comfort and fatigue when sitting, standing, and sit/standing. *International Journal of Industrial Ergonomics*, *29*(5), 289–296. https://doi.org/10.1016/S0169-8141(01)00069-5

Doroff, C. E., Langford, E. L., Ryan, G. A., & Snarr, R. L. (2019). Effects of active sitting on reading and typing task productivity. *International Journal of Exercise Science*, *12*(5), 1216–1224. https://doi.org/10.70252/MSYL8302

Fedewa, A. L., & Erwin, H. E. (2011). Stability balls and students with attention and hyperactivity concerns: Implications for on-task and in-seat behavior. *American Journal of Occupational Therapy*, *65*(4), 393–399. https://doi.org/10.5014/ajot.2011.000554

Gauthier-Lafreniere, E., Aljassar, M., Rymar, V. V., Milton, J., & Sadikot, A. F. (2022). A standardized accelerometry method for characterizing tremor: Application and validation in an ageing population with postural and action tremor. *Frontiers in Neuroinformatics*, *16*, Article 878279. https://doi.org/10.3389/fninf.2022.878279

Gibson, C., Folley, B. S., & Park, S. (2009). Enhanced divergent thinking and creativity in musicians: A behavioral and near-infrared spectroscopy study. *Brain and Cognition*, *69*(1), 162–169. https://doi.org/10.1016/j.bandc.2008.07.009

Goh, T., Hannon, J., Webster, C., Podlog, L., & Newton, M. (2016). Effects of a TAKE 10!® Classroom-based physical activity intervention on 3rd to 5th grades children's on-task behavior. *Journal of Physical Activity and Health*, *13*(7), 712–718. https://doi.org/10.1123/jpah.2015-0238

Graf, M., Krieger, R., Läubli, T., & Martin, B. (2015). *Should we recommend people to stand more than sit at work*. https://www.semanticscholar.org/paper/Should-we-recommend-people-to-stand-more-than-sit-Graf-Krieger/f4e0e668b2aeff9ee1968fd36082df391fd258d5

Greene, C. M., Murphy, G., & Januszewski, J. (2017). Under high perceptual load, observers look but do not see. *Applied Cognitive Psychology*, *31*(4), 431–437. https://doi.org/10.1002/acp.3335

Guilford, J. P., Christensen, P. R., Merrifield, P. R., & Wilson, R. C. (1960). *Alternate uses manual*. Mind Garden.

Guirado, T., Chambonnière, C., Chaput, J.-P., Metz, L., Thivel, D., & Duclos, M. (2021). Effects of classroom active desks on children and adolescents' physical activity, sedentary behavior, academic achievements and overall health: A systematic review. *International Journal of Environmental Research and Public Health*, *18*(6), Article 2828. https://doi.org/10.3390/ijerph18062828

Harrington, D. M., Block, J., & Block, J. H. (1983). Predicting creativity in preadolescence from divergent thinking in early childhood. *Journal of Personality and Social Psychology*, *45*(3), 609–623. https://doi.org/10.1037/0022-3514.45.3.609

Haydn, T. (2014). To what extent is behaviour a problem in English schools? Exploring the scale and prevalence of deficits in classroom climate. *Review of Education*, *2*(1), 31–64. https://doi.org/10.1002/rev3.3025

Howie, E. K., Beets, M. W., & Pate, R. R. (2014). Acute classroom exercise breaks improve on-task behavior in 4th and 5th grade students: A dose–response. *Mental Health and Physical Activity*, *7*(2), 65–71. https://doi.org/10.1016/j.mhpa.2014.05.002

Hulac, D. M., Aspiranti, K., Kriescher, S., Briesch, A. M., & Athanasiou, M. (2021). A multisite study of the effect of fidget spinners on academic performance. *Contemporary School Psychology*, *25*(4), 582–588. https://doi.org/10.1007/s40688-020-00292-y

Hulac, D. M., Mickelson, L. R., Briesch, A. M., Maroeca, H., Hartjes, C., Anderson, K., & Ederveen, K. (2022). Stability balls and student on-task behavior. *Journal of Behavioral Education*, *31*(3), 543–560. https://doi.org/10.1007/s10864-020-09412-3

Kazak, A. E. (2018). Editorial: Journal article reporting standards. *American Psychologist*, *73*(1), 1–2. https://doi.org/10.1037/amp0000263

Kercood, S., & Banda, D. R. (2012). The effects of added physical activity on performance during a listening comprehension task for students with and without attention problems. *International Journal of Applied Educational Studies*, *13*(1), 19–33.

Kuo, C. Y., & Yeh, Y. Y. (2016). Sensorimotor-conceptual integration in free walking enhances divergent thinking for young and older adults. *Frontiers in Psychology*, *7*, Article 1580. https://doi.org/10.3389/fpsyg.2016.01580

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). Lmertest Package: Tests in linear mixed effects models. *Journal of Statistical Software*, *82*(13), 1–26. https://doi.org/10.18637/jss.v082.i13

Langer, E. J. (1997). *The power of mindful learning* (pp. xii, 167). Addison-Wesley/Addison Wesley Longman.

Larson, M. J., LeCheminant, J. D., Hill, K., Carbine, K., Masterson, T., & Christenson, E. (2015). Cognitive and typing outcomes measured simultaneously with slow treadmill walking or sitting: Implications for treadmill desks. *PLOS ONE*, *10*(4), Article e0121309. https://doi.org/10.1371/journal.pone.0121309

Leuba, C. (1955). Toward some integration of learning theories: The concept of optimal stimulation. *Psychological Reports*, *1*(1), 27–33. https://doi.org/10.2466/PR0.1..27-33

Lorah, J. (2018). Effect size measures for multilevel models: Definition, interpretation, and TIMSS example. *Large-Scale Assessments in Education*, *6*(1), Article 8. https://doi.org/10.1186/s40536-018-0061-2

Ma, J. K., Le Mare, L., & Gurd, B. J. (2015). Four minutes of in-class high-intensity interval activity improves selective attention in 9- to 11-year olds. *Applied Physiology, Nutrition, and Metabolism*, *40*(3), 238–244. https://doi.org/10.1139/apnm-2014-0309

Marshall, M. R., Duckworth, S. C., Currie, M. R., Schmid, D., & Rogers, R. R. (2021). Role of age and sex on dual tasking using a treadmill desk while performing cognitive tests. *Gait & Posture*, *90*, 148–153. https://doi.org/10.1016/j.gaitpost.2021.08.013

Matin Sadr, N., Haghgoo, H. A., Samadi, S. A., Rassafiani, M., Bakhshi, E., & Hassanabadi, H. (2017). The impact of dynamic seating on classroom behavior of students with autism spectrum disorder. *Iranian Journal of Child Neurology*, *11*(1), 29–36. https://pubmed.ncbi.nlm.nih.gov/28277553/

Molloy, G. N. (1989). Chemicals, exercise and hyperactivity: A short report. *International Journal of Disability, Development and Education*, *36*(1), 57–61. https://doi.org/10.1080/0156655890360106

Office of Disease Prevention and Health Promotion. (n.d.). *Physical activity—Healthy People 2030*. Retrieved October 23, 2023, from https://health.gov/healthypeople/objectives-and-data/browse-objectives/physical-activity

Ofsted. (2014, September 25). *Low-level disruption in classrooms: Below the radar*. GOV.UK. https://www.gov.uk/government/publications/below-the-radar-low-level-disruption-in-the-countrys-classrooms

Olson, N. A., Panahon, C. J., & Hilt-Panahon, A. (2019). Investigating the effects of stability balls on classwide student behavior and academic productivity. *Journal of Applied School Psychology*, *35*(3), 201–214. https://doi.org/10.1080/15377903.2018.1549175

Oppezzo, M., & Schwartz, D. L. (2014). Give your ideas some legs: The positive effect of walking on creative thinking. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *40*(4), 1142–1152. https://doi.org/10.1037/a0036577

Organisciak, P., Acar, S., Dumas, D., & Berthiaume, K. (2023). Beyond semantic distance: Automated scoring of divergent thinking greatly improves with large language models. *Thinking Skills and Creativity*, *49*, Article 101356. https://doi.org/10.1016/j.tsc.2023.101356

Owen, K. B., Parker, P. D., Astell-Burt, T., & Lonsdale, C. (2018). Effects of physical activity and breaks on mathematics engagement in adolescents. *Journal of Science and Medicine in Sport*, *21*(1), 63–68. https://doi.org/10.1016/j.jsams.2017.07.002

R Core Team. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

Satterthwaite, F. E. (1946). An approximate distribution of estimates of variance components. *Biometrics Bulletin*, *2*(6), 110–114. https://doi.org/10.2307/3002019

Schaefer, S., Lövdén, M., Wieckhorst, B., & Lindenberger, U. (2010). Cognitive performance is improved while walking: Differences in cognitive–sensorimotor couplings between children and young adults. *European Journal of Developmental Psychology*, *7*(3), 371–389. https://doi.org/10.1080/17405620802535666

Schilling, D. L., Washington, K., Billingsley, F. F., & Deitz, J. (2003). Classroom seating for children with attention deficit hyperactivity disorder: Therapy balls versus chairs. *The American Journal of Occupational Therapy*, *57*(5), 534–541. https://doi.org/10.5014/ajot.57.5.534

Schmidt, M., Benzing, V., Wallman-Jones, A., Mavilidi, M.-F., Lubans, D. R., & Paas, F. (2019). Embodied learning in the classroom: Effects on primary school children's attention and foreign language vocabulary learning. *Psychology of Sport and Exercise*, *43*, 45–54. https://doi.org/10.1016/j.psychsport.2018.12.017

Skaalvik, E. M., & Skaalvik, S. (2017). Dimensions of teacher burnout: Relations with potential stressors at school. *Social Psychology of Education*, *20*(4), 775–790. https://doi.org/10.1007/s11218-017-9391-0

Slamecka, N. J., & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory*, *4*(6), 592–604. https://doi.org/10.1037/0278-7393.4.6.592

Sliter, M., & Yuan, Z. (2015). Workout at work: Laboratory test of psychological and performance outcomes of active workstations. *Journal of Occupational Health Psychology*, *20*(2), 259–271. https://doi.org/10.1037/a0038175

Snarr, R. L., Langford, E. L., Ryan, G. A., & Wilhoite, S. (2019). Cardiovascular and metabolic responses of active sitting while performing work-related tasks. *Ergonomics*, *62*(9), 1227–1233. https://doi.org/10.1080/00140139.2019.1633476

Stimson, R. C. (1968). Factor analytic approach to the structural differentiation of description. *Journal of Counseling Psychology*, *15*(4), 301–307. https://doi.org/10.1037/h0026005

Strasburger, V. C., Jordan, A. B., & Donnerstein, E. (2010). Health effects of media on children and adolescents. *Pediatrics*, *125*(4), 756–767. https://doi.org/10.1542/peds.2009-2563

Tüchsen, F., Krause, N., Hannerz, H., Burr, H., & Kristensen, T. S. (2000). Standing at work and varicose veins. *Scandinavian Journal of Work, Environment & Health*, *26*(5), 414–420. https://doi.org/10.5271/sjweh.562

van Hees, V. T., Renström, F., Wright, A., Gradmark, A., Catt, M., Chen, K. Y., Löf, M., Bluck, L., Pomeroy, J., Wareham, N. J., Ekelund, U., Brage, S., & Franks, P. W. (2011). Estimation of daily energy expenditure in pregnant and non-pregnant women using a wrist-worn tri-axial accelerometer. *PLOS ONE*, *6*(7), Article e22922. https://doi.org/10.1371/journal.pone.0022922

Waters, T. R., & Dick, R. B. (2015). Evidence of health risks associated with prolonged standing at work and intervention effectiveness. *Rehabilitation Nursing*, *40*(3), 148–165. https://doi.org/10.1002/rnj.166

Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D. (2017). Effect of classroom-based physical activity interventions on academic and physical activity outcomes: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), Article 114. https://doi.org/10.1186/s12966-017-0569-9

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag. https://doi.org/10.1007/978-3-319-24277-4_9

Zhou, Y., Zhang, Y., Hommel, B., & Zhang, H. (2017). The impact of bodily states on divergent thinking: Evidence for a control-depletion account. *Frontiers in Psychology*, *8*, Article 1546. https://doi.org/10.3389/fpsyg.2017.01546

Received November 10, 2023
Revision received May 14, 2025
Accepted May 19, 2025 ■