Middle school-based interventions for childhood ADHD

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https://doi.org/10.38126/JSPG240113
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Keywords: attention deficit/hyperactivity disorder; physical activity; virtual reality; special education

Executive Summary: Given that the United States has the highest prevalence rate of child attention deficit/hyperactivity disorder (ADHD) in the world, the author expands on the findings of Rahim and Geng (2023) that reviews recent evidence on the effectiveness of different interventions currently clinically and experimentally employed to alleviate pediatric ADHD symptoms. Results from the present analyses suggest several options; as the United States Congress considers policy pertinent to children's education, incorporation of alternative ADHD treatment methods into middle school educational settings may be the catalyst to improve this population's outcomes in STEM education in relation to their predominant symptoms.

I. General background

Attention deficit/hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders to affect American children and adolescents (hereafter referred to as "children"), wherein the United States has the highest rate of children diagnosed with this disorder in the world (8.7%; Abdelnour et al. 2022). Prevalence rates of child ADHD are rising, though this may be due in part to a growing understanding among clinicians of pediatric ADHD symptomatology (Abdelnour et al. 2022). Though this disorder is characterized mainly according to children's proneness for inattention and/or impulsivity, they also show deficits in selective attention—the ability to focus on a target stimulus while ignoring distractions. This set of symptoms hinders students' abilities to succeed in STEM education, as this capacity is crucial for faculties like in-depth reading, critical thinking, and multi-step mathematical manipulation (Merkley, Matusz, and Scerif 2018). While children's symptoms can have positive and negative functional implications (Bondü and Esser 2014), it is important to recognize that their well-being affects the economic health of families and society overall (Lindly et al. 2021). This context motivates the development of systemic initiatives for supporting these students.

II. Current legislative landscape

Two pieces of federal legislation are capstones of the current landscape for educating children with ADHD and are superordinate to state and local laws. Both laws provide guidance on individual accommodations for students with ADHD (and other diagnoses potentially impacting educational outcomes) and are reassessed on an annual basis to continually monitor and update students' progress and developing needs.

The Individuals with Disabilities Education Act of 1975 established that all students with documented disabilities in schools receiving federal funding shall receive free and individually appropriate public education while below the age of 21 through implementation of an individualized education plan of reasonable accommodations. This plan must include information on: 1) the child's current level of performance on a battery of assessments and caregiver evaluations, 2) a set of annually reviewed goals, 3) a list of special education accommodations (e.g. preferential seating), and 4) a description of how progress will be tracked.

Additionally, section 504 of the Rehabilitation Act of 1973 prohibits discrimination against individuals

with disabilities in any environment that receives federal funds, and addresses how the personalized accommodation plan will be practically implemented in educational settings. This allows students access to a diverse array of behavioral modifications in the classroom, tailored to their individual needs (e.g., use of a fidget device). Both of these legislative structures carry the drawback of variable implementation—depending on the teacher's (often limited) bandwidth to provide these accommodations, students may or may not have their needs addressed.

Representative Raúl Grijalva (D-AZ-7) recently introduced H.R.1578, the Success in the Middle Act of 2023. This piece of legislation would provide discretionary grants through the Department of Education to analyze current conditions and "create statewide improvement plans to improve student academic achievement in the middle [school] grades" (U.S. Congress 2023). While this bill mainly focuses on devising methods to improve neurotypical students' educational outcomes, it also stresses the need to adopt innovative methods to progress outcomes for students requiring special education needs. As middle school is a particularly formative time for children with ADHD, this policy focus potentially bodes well.

III. Current accommodated education landscape

The U.S. Department of Education's National Center for Special Education Research (NCSER) branch is charged with conducting research to determine how to improve educational opportunities and outcomes for children with disabilities, including research on novel methods that would fall under the purview of H.R.1578.

Most children with ADHD are taught in general education classrooms (Centers for Disease Control and Prevention n.d.). School-based interventions largely rely on teachers delivering individualized behavioral modifications to students needing accommodations (Conway et al. 2019), supplementing clinically derived interventions. Given the significant pressures on teachers, these needs may or may not be met.

Established treatments for pediatric ADHD (e.g., medication, counseling) are widely employed to manage children's symptoms. Given that these treatments are only moderately effective, there is a marked need to broaden the scope of interventions implemented. While several studies have assessed these methods according to a single evaluative factor (Sampaio et al. 2021), Rahim and Geng (2023) conducted a methodical search of systematic reviews and meta-analyses that surveyed both established and experimental interventions (Appendix A, Item 1) relative to four factors for a more holistic view of each method's individual efficacies:

1. Effect size: the difference in measured outcome between the group receiving the intervention versus not
2. Transfer: ability to evoke carry-over effects from the treatment task to a functional one (e.g., academic performance)
3. Cost-effectiveness: researchers' assessments of how financially prudent employing the intervention is, given effects on users' health
4. Safety: researchers' assessments of risk of incurring side effects

	Factors	Effect Size	Transfer	Cost-effectiveness	Safety
	Rating	strong: >/= 0.8 medium: >/= 0.5 weak: >/= 0.2 very weak: < 0.2	2: training during the intervention carried over to a different task outside of the intervention 1: training during the intervention carried over to a similar task 0: training in the intervention had no effect outside of its direct training	most effective: </= $4097 medium effective: </= $8194 medium ineffective: </= $12291 most ineffective: > $12291	2: side effects are temporary or generally negligible 1: tend to be long term 0: directly carry serious risk
Interventions	Medication	0.18 n = 2 (7)	1.5 n = 2	$13,736 n = 1 (8)	1.6 n = 23
	Counseling	0.50 n = 4	1.0 *college students with ADHD n = 1	$3,942 n = 3 (4)	N/A
	Computer training	0.45 n = 2 (8)	1.5 n = 2	N/A	2.0 n = 2
	Physical activity	0.60 n = 8	2.0 n = 1	$265 *geriatric n = 1	2.0 n = 2
	Mobile applications	0.20 n = 2 (6)	1.0 n = 1	$3,492 *various n = 2	2.0 n = 1
	Neuromodulation	0.30 n = 6 (12)	N/A	$15,245 n = 3 (4)	1.8 n = 8
	Virtual reality (non-immersive)	-0.10 n = 1 (1)	N/A	N/A	N/A
	Virtual reality (semi-immersive)	0.57 n = 4 (7)	2.0 n = 1	$15,911 *adults with psychosis n = 2	1.0 n = 2
	Virtual reality (fully immersive)	N/A	N/A	$16,388 *adults with back pain n = 1	1.0 n = 2
	Augmented reality	N/A	N/A	N/A	1.0 n = 1

Figure 1. Summary of findings from analyses of Rahim and Geng (2023), comparing average values/ ratings of several factors important for gauging the effectiveness of the reviewed interventions†. Number of papers (n) reviewed includes the number of meta-analyses and systematic reviews evaluated, with the number of individual papers assessed in parentheses. Asterisks indicate that the effectiveness measure was obtained in a different population than children with ADHD.

This review revealed that each intervention carries its own unique set of advantages and disadvantages. These results were further analyzed to compare efficacies and reveal potentially optimal methods. An additional literature search was conducted to fill in gaps of knowledge remaining after the systematic search of Rahim and Geng (2023). The author rated textual evidence according to set criteria for Factors 1, 2 and 4 and aggregated incremental cost-effectiveness ratios for Factor 3 for each intervention. The numerical data were then averaged (Figure 1).

Though there are gaps in the literature, results suggest that both structured exercise-based physical activity ("PA") and semi-immersive virtual reality ("SIVR") may be effective modes of intervention for improving the adverse symptoms of pediatric ADHD (e.g., failure to inhibit impulses, poor sustained attention). By administering assessment(s) before and after the intervention, its effect may be gauged.

PA training generally involves participating in structured exercise regimens (e.g., jumping jacks, distance running). While training intensity moderates how effective training is (Varigonda, Edgcomb, and Zima 2020), PA is known to improve socialization behaviors, support the ability to focus and maintain attention, and inhibit other function-interfering behaviors (Benzing and Schmidt 2019).

SIVR is a particularly powerful tool for simulating real-life experiences, allowing children with ADHD to undergo controlled training in completing academic tasks. A common training approach is to generate a virtual classroom with a teacher standing by a blackboard delivering instructions while other students whisper to each other or move around the scene, requiring the user to perform a task amid these distractions. This method has been useful for helping children decrease inattentiveness and ignore distracting visual and audio stimulation (Stokes et al. 2022).

While preliminary research shows that PA and SIVR may be effective interventions for childhood ADHD (Rahim and Geng 2023), more research is required to determine how well they can be put into practice.

IV. Policy options

To harness the potentially powerful academic outcomes that would result from passage of

H.R.1578 to support middle schoolers with ADHD, the author suggests incorporating the following policy options to improve management of pediatric ADHD:

i. Option 1

Establish a collaboration between researchers and educators through partnerships with organizations such as the NCSER to develop evidence-based SIVR intervention protocols, specialized to address the student's individualized symptoms. Execute this protocol via a well-sampled pilot study in representative school districts.

Advantages

As scheduled breaks are one of the most common accommodations employed through section 504, creating a protocol for use of SIVR within this time allows for more efficient time management. As children with ADHD are motivated to use this technology, the author does not anticipate that filling this previously empty period will strain the students' cognitive resources that initially prompted the break and may in fact reinvigorate these students' attentional capacities (Dekkers et al. 2017). SIVR has been shown to be safe and effective, showing positive results in generalizing from the trained task to functional tasks like those foundational for successful academic performance (Corrigan, Păsărelu, and Voinescu 2023; Parsons, Duffield, and Asbee 2019). As SIVR tasks are highly flexible, this intervention can be readily adapted to accommodate a student's needs.

Disadvantages

A major disadvantage of SIVR is the relatively low cost-effectiveness of this nascent technology, driven by its high costs of development (Pot-Kolder et al. 2020; Figure 1). With the proposed budget allocated to districts by H.R.1578 (as determined by a function of the number of students requiring special education services and the relative poverty level of the students), it may not be feasible to incorporate SIVR in all school districts. However, the National Institutes of Health are in the early stages of developing open-source platforms for other applications that would substantially reduce the funding required to ensure equitable treatment access (Won et al. 2021). High up-front costs should be considered a long-term investment though, as successful administration would likely reduce these students' reliance on government aid over time (Williams and Musumeci 2021). Additionally, because this method only simulates being in the virtual environment but does not allow its manipulation, students do not gain the benefits of actively "going through the motions" that benefits skill learning such that benefits may be incomplete. Finally, training an assistant to administer the protocol and monitor the student during training would require additional resources.

ii. Option 2

Through the collaborations suggested in Option 1, develop a protocol for a PA intervention. Execute this protocol via a well-sampled pilot study in representative school districts.

Advantages

PA is a notably safe, symptom-improving, and cost-effective intervention (Huang et al. 2022). Thus, a wider range of school districts will have access to execute these pediatric ADHD protocols compared to SIVR, which is especially important as districts with less income tend to also have more students with ADHD (Bozinovic et al. 2021). While more research is needed in this area, benefits of PA training during breaks have been shown to improve academically relevant functional outcomes (Range, Carnes-Holt, and Bruce 2013).

Disadvantages

Where children are leading increasingly sedentary lifestyles, it may be difficult to maintain children's engagement with the task. "Gamifying" the activity by including rewarding feedback (via verbal encouragement, prizes, etc.) may incentivize participation. Though children are already monitored during their scheduled break time, this task-oriented break would require the presence of a PA-trained educator, which may pose a budgetary and access concern. Intervention protocols should also be inclusive of students with physical disabilities, adapting to meet the student's needs.

iii. Option 3

Administer parallel pilot programs outlined in Options 1 and 2 in representative school districts (based on a cost-benefit analysis incorporating demographic and socioeconomic factors), such that upon nationwide expansion each school district may

self-determine whether it will employ the PA or SIVR protocol.

Advantages
If the intervention used is determined by each local educational agency's individual cost-benefit analysis, school districts may address these students' needs while keeping on track with budgetary constraints.

Disadvantages
Even with representatively sampled school districts being selected for the pilot study, generalizing across districts poses a significant challenge. As there are marked differences among districts and states in demographics, economic status, and legislative context, expanding the pilot program would require further consideration for school districts' unique aspects. While this concern is not unique to this far-reaching educational proposal, this targeted approach allows for greater specificity than a blanket one.

iv. Option 4
In the case of Congressional inaction, the status quo will be maintained for children with ADHD receiving federally funded middle school education.

Advantages
No additional funding resources will be required from the DOE to provide support for children with ADHD while at school.

Disadvantages
Students with ADHD will continue to be affected by the atypical and adverse symptoms of this disorder at current, interfering levels. While incorporating such interventions requires an upfront cost, they also present the possibility of mitigating future costs and improving this population's quality of life as they develop (Conway et al. 2019).

V. Limitations

These policy proposals hold potential qualifications, including that adopting these policy options at this time is contingent on H.R. 1578 being passed into law. As only 5% of bills on education reform for students with disabilities were adopted in the 117th Congress (U.S. Congress n.d.), this may not come to fruition. In addition, while the evidence collected in Rahim and Geng (2023) was derived from systematic reviews and meta-analyses that pooled across similar articles to give a more comprehensive view of the literature as compared to individual articles, the present review was conducted on a relatively sparse and notably heterogeneous literature base. While this proposal extrapolated from what little is known, the positive preliminary findings suggest that this direction should be probed further (as was outlined in H.R. 1578 section 202 (c) (3)).

VI. Policy recommendations

To implement policy that advances educational access to all middle school aged American children, the author recommends passing H.R.1578 and specifically harnessing it to address the distinct needs of children with ADHD by appropriating $2.1 million (Appendix A, Item 2) (<1% of H.R.1578's proposed first year's budget) to implement the pilot program outlined in Option 3 (calculated as the cumulative cost of administering 50 students each through either the PA or SIVR protocol, as well as the cost of protocol development), as it seeks to advance students' outcomes in a cost-effective manner. By forging an alliance between middle school educators and researchers, advances in pediatric ADHD management can be more readily incorporated into widely used treatment protocols.

While some classroom accommodations will likely still need to be administered, diversifying the method of symptom relief for children with ADHD reduces pressure on already overburdened educators from providing frontline services. There is much work that needs to be done to improve the outcomes of children with ADHD. Incorporating structured interventions into school curricula for use at strategic times may be a favorable mode of action to further this population's performance, particularly in their ability to engage in STEM education.

Appendix A:

Item 1. Adapted from Rahim and Geng (2023)

Term	Definition
Medication	non-supplemental pharmaceuticals
Counseling	psychological training gained through e.g., meeting with a psychologist or self-reflecting
Computer training	computerized training on tasks (e.g., visual search) without an avatar
Physical activity	structured exercise at various levels of intensity
Mobile applications	training delivered via computer application
Neuromodulation	neural stimulation (via e.g., electroencephalography)
Virtual reality (non-immersive)	computerized training with the goal of navigating an avatar through a virtual environment
Virtual reality (semi-immersive)	computerized training where the user passively adopts an avatar's perspective by wearing a headset, responding to stimuli in a virtual environment
Virtual reality (fully immersive)	same as semi-immersive, except a hand controller allows active interaction with the virtual environment
Augmented reality	user navigates real-world environment augmented with virtual elements

Item 2. This figure was calculated using the following formula:

50 * (cost of PA/ student) + 50 * cost of SIVR/ student) + 20 * (cost of NCSER protocol development and pilot study execution for 1 year*)

* as reported on Glassdoor (2024)

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