Associations between attention problems and intensity of movement in adolescence

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Introduction

- ADHD, or **attention deficit/hyperactivity disorder**, is the most common psychiatric disorder in children.[1]
- However, current measures to capture adolescent behavior are limited. Performance based lab tasks are time consuming and lack ecological validity, while rating scales are affected by mono-informant bias and interpersonal discrimination.[2, 3]
- In childhood, ADHD manifests itself in physical behaviors like moving from place to place frequently that wearable device sensors are well suited to capture.[4] Sensor data offers a new perspective by yielding a high volume of ecologically valid, objective observations that capture variability within-child.[5] Yet, previous studies only describe mean activity and discard rich temporal information about daily behavior.[6, 7]

➢ **Does temporal data on adolescents' intensity of movement correlate with report-based measures of ADHD symptoms?**

Methods

Sample & Protocol — The **Adolescent Brain Cognitive Development** (ABCD) Study is a population-based sample of children from 21 research sites across the US.

- **About our sample**: n = 6257; 66% Non-Hispanic white, 18% Hispanic, 18% Black, 12% Asian, 5% Native, 6% other; 48% female
- **Fitbit Protocol**: The Fitbits were worn every day for three weeks for at least 600 minutes of daytime wear, identified as non-sleep hours. Data collected over summer months and weekends were excluded.

Measures — The Fitbit activity data, **Child Behavior Checklist** (CBCL), and **Brief Problem Monitor** (BPM) were collected in the 2 year follow-up when the children were aged 11-12 (ABCD Annual Release 5.0).

- **Daytime Activity Level**: Using Fitbit data at the daily level, we calculated children's average intensity of movement during non-sleep hours measured in a unit of energy expenditure called **Metabolic Equivalent Tasks**, or **MET**s (1 MET = resting metabolism of an average individual). We also calculated children's variability in their intensity of movement from day to day (i.e., standard deviation across 15 days).
- **Child Behavioral Problems**: Parents reported on attention and externalizing problem subscales on the CBCL.[8] Teachers and youth reported on attention and externalizing behaviors using the BPM.[9] We used raw scores in our analyses.

Analysis — Figures 1, 2, and 3 show bivariate associations. Figure 4 shows estimates from a linear regression model to assess whether mean activity and day-to-day variability show unique associations with teacher reports of attention after accounting for sex differences and site.

Results

Figure 1
Correlations between Reports of **Externalizing** Problems & Child Mean Activity and Day-to-Day Activity Variability

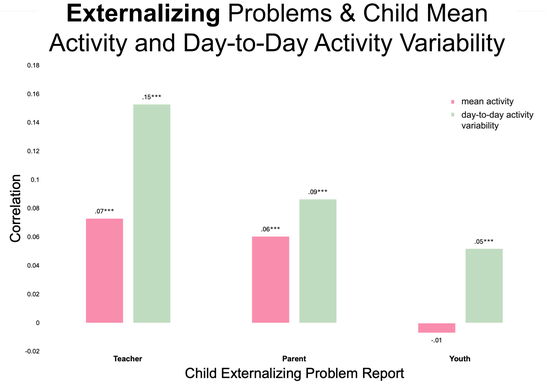


Figure 2
Correlations between Reports of **Attention** Problems & Child Mean Activity and Day-to-Day Activity Variability

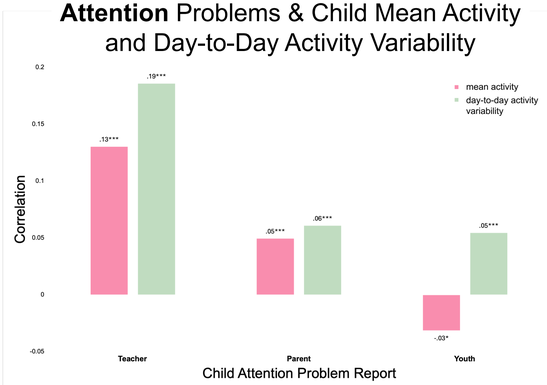


Figure 3
Associations between Day-to-Day Activity Variability and Teacher-Reported Attention Problems

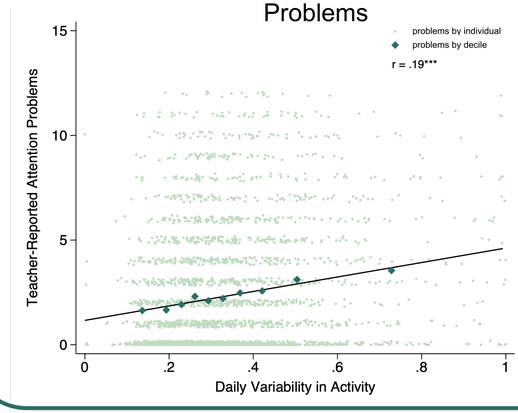
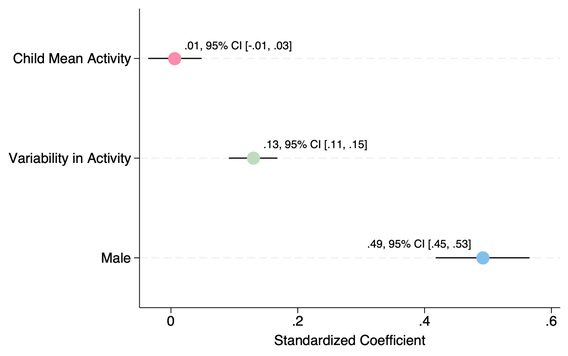


Figure 4
Teacher-Reported Attention Problems



Discussion

Results

- Unlike other measures of daily activity which only consider the mean activity levels, sensor actigraphy data allows for unique insights into the relationship between within-child activity variability and ADHD symptoms.
- Actigraphy is a promising way to assess children's impulsive and inattentive behavior in everyday settings. Using actigraphy data could help us remedy disparities in the rate of ADHD diagnoses in historically under-diagnosed groups like Black youth and girls.

Limitations

- Our measure included all daytime hours– both in-school and out-of-school– so it is unclear if these associations are driven by, or weakened by, after-school activities.

Future Directions

- The ABCD study includes a large, diverse sample with a broad scope of measures. This dataset could provide insights into whether the association between activity levels and ADHD symptoms is moderated by various factors. For example, is the association stronger in hotter climates, with insufficient sleep, or in neighborhoods with fewer green spaces?
- Further research into the associations between actigraphy and ADHD symptomatology could generate a scalable screening tool or a means of remote symptom monitoring for clinicians.

References

(1) CDC. (2022, June 3). *Data and Statistics on Children's Mental Health | CDC*. Centers for Disease Control and Prevention. https://www.cdc.gov/childrensmentalhealth/data.html
(2) Soto, E. F., Kofler, M. J., Singh, L. J., Wells, E. L., Irwin, L. N., Groves, N. B., & Miller, C. E. (2020). Executive functioning rating scales: Ecologically valid or construct invalid? *Neuropsychology*, 34(6), 605–619. https://doi.org/10.1037/neu0000681
(3) Nyongesa, M. K., Ssewanyana, D., Mutua, A. M., Chongwo, E., Scerif, G., Newton, C. R. J. C., & Abubakar, A. (2019). Assessing Executive Function in Adolescence: A Scoping Review of Existing Measures and Their Psychometric Robustness. *Frontiers in Psychology*, 10. https://doi.org/10.3389/fpsyg.2019.00311
(4) Gawrilow, C., Kühnhausen, J., Schmid, J., & Stadler, G. (2014). Hyperactivity and Motoric Activity in ADHD: Characterization, Assessment, and Intervention. *Frontiers in Psychiatry*, 5. https://doi.org/10.3389/fpsyt.2014.00171
(5) Barbaro, K. (2019). Automated sensing of daily activity: A new lens into development. *Developmental Psychobiology*, 61(3), 444–464. https://doi.org/10.1002/dev.21831
(6) Brandt, V., Patalay, P., & Kerner auch Koerner, J. (2021). Predicting ADHD symptoms and diagnosis at age 14 from objective activity levels at age 7 in a large UK cohort. *European Child & Adolescent Psychiatry*, 30, 877-884. https://doi.org/10.1007/s00787-020-01566-9
(7) Willoughby, M. T., Wylie, A. C., & Catellier, D. J. (2018). Testing the association between physical activity and executive function skills in early childhood. *Early Childhood Research Quarterly*, 44, 82-89. https://doi.org/10.1016/j.ecresq.2018.03.004
(8) ASEBA. (2001). *Child Behavior Checklist (CBCL)*. https://www.apa.org/depression-guideline/child-behavior-checklist.pdf
(9) Piper, B. J., Gray, H. M., Raber, J., & Birkett, M. A. (2014). Reliability and validity of Brief Problem Monitor, an abbreviated form of the Child Behavior Checklist. *Psychiatry and Clinical Neurosciences*, 68(10), 759–767. https://doi.org/10.1111/pcn.12188

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