Using Simulators to Assist with Healthcare Issues: The Impact of a Sailing Simulator on People with ADHD

Gurdeep Sarai,[1] Oren Tirosh,[1]
Prem Prakash Jayaraman,[2] Peter Brooks,[3]
Norman Saunders,[4] Nilmini Wickramasinghe[5]

[1] Swinburne University of Technology, Faculty of, Health Science, Melbourne, Australia
gurdeep.sarai@gmail.com, otirosh@swin.edu.au
[2] Swinburne University of Technology, School of Science, Computing and Engineering Technologies, Melbourne, Australia
pjayaraman@swin.edu.au
[3] University of Melbourne, Faculty of Medicine, Dentistry and Health Sciences, Melbourne, Australia
brooksp@unimelb.edu.au
[4] University of Melbourne, Faculty of Neuroscience, Melbourne, Australia
n.saunders@unimelb.edu.au
[5] Swinburne University of Technology, Faculty of Health Science/Digital Health, Melbourne, Australia
nwickramasinghe@swin.edu.au

The use of simulators has grown a vast amount in the past few years, with various research reports on the advantages that come with the use of this technology. However, the use of simulators as a form of treatment/aids have yet to be fully embraced. Given the growing diffusion of technology, many people can benefit from simulators that are more accessible and improve specific qualities to help them cope with their deficiencies. To examine this current void, this research in progress examines the benefits of physical activity for people with attention deficit hyperactivity disorder (ADHD) through the use of a VSail Sailing Simulator. Specifically, we contend that there are benefits to addressing strength and balance. Thus, this paper analyzes the ramifications of the findings, along with knowledge gaps and a research plan.

Keywords: simulators, ADHD, physical activity, intervention, sailing simulation, motor function

University of Maribor Press

DOI https://doi.org/10.18690/um.fov.6.2023.30
ISBN 978-961-286-804-8

1 Introduction

The COVID-19 pandemic has caused a significant increase in mental health issues, leading to a surge in the number of adults being prescribed ADHD medication in Australia. According to the Australian Department of Health and Aged Care, the number of patients receiving ADHD medication has grown at an annual rate of 12.43%, with a higher growth rate of 16% observed from 2018-2020. This growth rate is almost double that of the growth rate from 2014-2017 (9%) and serves to highlight the importance to address this issue. The number of prescriptions has also increased, with an average annual growth rate of 10.25% and the highest growth rate of 17.67% observed from 2018-2020. As a result, more adults are now receiving ADHD medication than children.

Attention-deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder that affects individuals across the lifespan. The global prevalence of ADHD in children is estimated to be around 5%, while in adults, it is around 3-4% (Polanczyk and Rohde, 2007, Shaw et al. 2007, AADPA). In early childhood, symptoms of ADHD may include impulsiveness, hyperactive behaviour, and low frustration tolerance. Longitudinal neuroimaging studies indicate that children with ADHD may be 2-3 years behind their peers in development. In adulthood, individuals with ADHD may experience memory problems, restlessness, and difficulty with mental focus. Notably, 4-11% of university students exhibit symptoms of ADHD (AADPA).

Separate from this, yet contemporaneous, have been the advances in technology and simulation solutions. In this paper, we outline research in progress work that aims to address the larger key research question of "What is the degree of fidelity with which a sailing simulator can reproduce the health benefits associated with real-life sailing?". This research in progress paper contribution is towards the feasibility of using inertial measuring units (IMU) to identify hand movement patterns and motor assessments that are beneficial in real-life sailing. The primary objectives of the research-in-progress paper are:

1. Objective 1: To measure the effect of sailing simulation on grip strength and postural balance in non-ADHD and ADHD participants

2. Objective 2: To measure the acceleration patterns of both hands in a sailing simulation between ADHD and non-ADHD students.
3. Objective 3: To understand the participant's perception of ADHD therapies and simulators as a part of their therapy.

The research design employs a grounded theory mixed methods approach, incorporating both quantitative and qualitative methodologies. The quantitative aspect focuses on examining the effectiveness of IMUs in measuring various aspects of sailing simulation, including motor assessments. Whilst the qualitative perspective delves into exploring the perceptions and attitudes of individuals with ADHD towards ADHD therapy and the use of simulation as therapy. By combining both quantitative and qualitative data, we can understand how sailing simulation can influence grip strength and postural balance, along with the perception and acceptance of sports simulators as a therapeutic intervention for individuals with ADHD. Preliminary testing has been conducted to consider all critical IMU aspects of the proposed research plan.

2 Related Work

2.1 Physical Activity and ADHD

Regulating the course of neural development has the potential to improve ADHD symptoms, suggesting that interventions targeting neural growth and development will be more effective than other treatments. Non-pharmacological treatments such as cognitive-based therapies or physical activity have demonstrated effectiveness. Engaging in physical exercise is one of the most advantageous strategies for treatment, providing numerous benefits and reducing symptoms (Xie et al. 2021). Physical therapy leads to enhanced coordination and motor function, while mental health improvements include processing speed, selective attention, and cognitive flexibility (Montalva-Valenzuela et al. 2022, Watemberg et al. 2007). However, challenges exist in introducing physical activity as a treatment for ADHD, with dropout rates of 17.5% (Vancampfort et al, 2016). This suggests a need for better engagement strategies and further studies to explore other forms of physical activity (Carta et al, 2014).

2.2 Physical Activity based Interventions

Physical exercise has a positive impact on health and well-being, including improving mood, quality of life, and mitigating stress. Research on physical activity and ADHD supports using exercise as an intervention strategy. Aquatics exercise programs and racquet sports have shown efficacy in improving cognitive, behavioural, and motor functions in children with ADHD. Sailing also offers numerous benefits for mental and physical health, including enhancing concentration, communication, mental wellness, endurance, and muscle strength. It has shown positive outcomes in improving quality of life, global functioning, social skills, outlook on life, and mental and physical health for individuals with disabilities and severe mental illnesses. Sailing may be a promising intervention for enhancing well-being, particularly for those with mental illnesses, and may be more engaging than standard rehabilitation methods.

2.3 Simulator Based Interventions

Simulators are effective tools for adaptive training, which adjusts the task's complexity to the user's skill level. They can break down cognitive activities into components that are difficult to train individually. For example, simulators can introduce factors involved in sailing gradually, preventing the operator from becoming overwhelmed. Studies using a horse-riding simulator have yielded positive results in various populations. A study by Borges et al. (2011) revealed that children with cerebral palsy spastic diplegia showed greater emotional happiness and overall satisfaction with the simulator than with conventional physical therapy. The simulator was also statistically superior in increasing postural control in a seated position compared to conventional therapy. Other studies have demonstrated the simulator's potential to enhance physiological functioning in elderly individuals, such as postural control, muscle activation, and dynamic stability (Mitani et al. 2008, Kim and Lee, 2015).

3 Research Design

3.1 Participants

Study participants are divided into two groups: "non-ADHD" students and "ADHD" students aged 18-30. Both groups are screened for physical conditions and injuries. The ADHD group includes students with self-diagnosed ADHD. Participants complete the APSS Screening Tool to determine those more vulnerable to adverse events caused by exercise. The ASRS-V1.1 Symptom Checklist is used for self-diagnosis of ADHD symptoms in the ADHD group.

3.2 Apparatus

Sailing Simulator: The simulator itself is a VSail-Trainer®, designed by the company Virtual Sailing Pty Ltd. It comprises one boat hull (size length: 230 cm, breadth: 150 cm). The simulator allows sailors to control the course and speed of the boat using a joystick and mainsheet, whilst being in a seated setup suitable for disabled individuals. The simulator has a range of tools and functionalities for researchers to design experiments around, such as the ability to adjust environmental conditions, boat characteristics, and sailor behaviours.

The Inertial Measuring Unit (IMU) is a form of accelerometer, composed of an electromechanical sensor that is designed to measure dynamic acceleration. In this case, two IMUs are placed on the back of each hand of the participant. This will look at the change in velocity for the rudder movement and mainsheet.

The Jamar hand dynamometer will be used to measure isometric grip force in the participants pre- and post-trial as part of their motor assessment.

3.3 Movement Assessment

Studies suggest that postural instability in adults with ADHD may contribute to difficulties with motor coordination and everyday activities related to balance and postural control. Grip strength differences in individuals with ADHD may be influenced by a combination of motor coordination deficits, attentional deficits, and medication use. The relevance of grip strength and postural balance in real-life sailing has been shown to improve both areas. Participants will undergo a pre and post-simulator training movement assessment. The first motor assessment test will be the strength component (Hove, et al. 2015, Jansen, et al.2019, Jeoung, et al. 2014, Neely, et al. 2017, Clarke, et al. 2020). The Jamar hand dynamometer will be used to assess grip strength before and after each scenario. Balance will be assessed through a force plate or through a Balance Error Scoring System to assess overall static balance before and after each scenario.

3.4 Interviews

Semi-structured interviews can provide valuable insights into the perception and acceptance of sports simulators as a therapeutic intervention for individuals with ADHD. Including whether individuals with ADHD would be willing to use sports simulators regularly, and investigating potential benefits such as improved motor skills and ADHD symptoms, along with potential drawbacks. This can help with the development of more effective interventions for individuals with ADHD. The interviews are conducted with a consistent set of questions, while the order of the questions may be adjusted based on responses.

4 Data Collection

4.1 Participant setup

Before testing begins each participant is briefed on the simulator, equipment, and safety features. Participants sign a consent form and wear two IMUs on their hands. After being seated in the V-Sail simulator, participants are given an adaptation period to learn how to sail using the information provided in the HUD. Steering is introduced first, followed by the main sheet, teaching participants how to adjust the main sail and coordinate the boat's speed based on wind direction. Participants also learn maneuvers such as tacking and aligning the twin tails on the mainsail to use the wind to their advantage. The final step is to introduce the pneumatic rams, which allow participants to understand how the boat handles at certain angles relative to the wind.

4.2 Sailing Program

Participants will train on a Sydney 2000 Olympic Games Trapezoid course in the Sydney harbour. The course involves sailing upwind to the first buoy, then downwind past three buoys, and back upwind. The training program consists of 6 sprints per week for three weeks, with each sprint lasting 3-4 minutes on average. The sprints progressively increase in difficulty and challenge the participants' decision-making and technique accuracy. The wind speeds will be implemented through a blocked and serial schedule in the first and final weeks.

4.3 Data Analysis

Pre and Post Movement Assessment: The measurements obtained for both sets of pre and post scenarios are evaluated. To evaluate whether the mean difference between the two sets of data varies, a paired sample t-test is performed.

IMUS:

1. Average acceleration magnitude (AAM): The standard deviation of acceleration from the mean. More task stability is indicated by smaller values.
2. Root mean square (RMS): An evaluation of the fluctuating signal strength. Significant stability is indicated by smaller values.

Interviews: Thematic Analysis

5 Preliminary Findings

The pilot study aimed to determine if IMU placement and hand movement are appropriate measures for testing and comparing real-life sailing. The study collected data from a healthy participant using two IMUs on the back of both hands in three different wind conditions (8, 12, and 16 knots). The approach was based on a previous study by Mackie and Legg (1999) that focused on how force output varies with wind speed, finding that force on the mainsheet increases with higher winds. Mackie and Legg (1999) also found a trend between force and wind through experience level in sailing. Specifically, the mainsheet force increased for club sailors with less experience, while the opposite trend was found for pro sailors. This is due to differences in sailing techniques found with experience as conditions get more difficult.

Table 1: Differences between both hands and the wind speed, expressed as an average acceleration magnitude (AAM) and root-mean-squared (RMS)

	Hand	8 Knots Wind Speed	12 Knots wind speed	16 Knots wind speed
Average acceleration magnitude (AAM) (m/s^2)	Left (Tiller)	9.52	9.53	9.56
	Right (Mainsheet)	9.76	9.76	9.8
Root mean square (RMS) (m/s^2)	Left (Tiller)	5.51	5.52	5.54
	Right (Mainsheet)	5.66	5.67	5.68

The study aims to quantify the difference in acceleration for hand movement between ADHD and healthy students. The preliminary study showed variability in both AAM and RMS parameters with increasing wind speed. At 8 and 12 knots wind speed, there were similarities in the acceleration of both hands, while 16 knots showed less stability during the sprint. The results are consistent with Mackie and Legg's study, which found higher force in the mainsheet between wind speeds of 15-20 knots. The findings of the IMU showed an increase in acceleration for both hands as wind speed increased, similar to real-life sailing. The methodology allowed for finding variability in the set conditions in the simulator. Through the research, we can observe how the movement patterns of students with ADHD differ from those of healthy students in the sailing simulator, and how these patterns progress with experience.

This study has a few parts worth considering and should help inform future research directions. With this research looking at the feasibility of IMUs future research will be focusing on using the IMUs towards the comparison of movement in real-life sailing. Future Research In this current generation of human and computer interaction, simulator use will also provide insight into values, interests, and user experience giving a good basis for how simulators are taken as a form of therapy in managing ADHD.

6 Conclusion

This research in progress study has served to highlight a potential role for the use of simulators to address mental health/mental wellness issues. Specifically, we have focused on the benefits of a sailing simulator to assist students with ADHD. To date, the application of simulators to assist with addressing mental health/ mental wellness issues is embryonic at best; but we contend that the potential benefit of this approach justifies more research in this area. We believe our study will serve as one of the first to shed light on this major area.

Acknowledgements

This work was supported by Swinburne University of Technology and Research under the SUPRA program, in partnership with Northern Health and Virtual Sailing. This endeavor would not have been possible without the support of the Virtual Sailing team Norman Saunders, Mark Habgood and Jonathan Binns. Along with the added support by Northern Health from Peter Brooks.

References

BARKLEY, R. A., FISCHER, M., SMALLISH, L. & FLETCHER, K. 2002. The persistence of attention-deficit/hyperactivity disorder into young adulthood as a function of reporting source and definition of disorder. Journal of Abnormal Psychology, 111, 279-289.

BEHRMANN, J. T., BLAABJERG, J., JORDANSEN, J. & JENSEN DE LÓPEZ, K. M. 2022. Systematic Review: Investigating the Impact of COVID-19 on Mental Health Outcomes of Individuals With ADHD. Journal of Attention Disorders, 26, 959-975.

BELL, D. R., GUSKIEWICZ, K. M., CLARK, M. A. & PADUA, D. A. 2011. Systematic review of the balance error scoring system. Sports Health, 3, 287-95.

BORGES, M. B. S., WERNECK, M. J. D., DA SILVA, M. D., GANDOLFI, L. & PRATESI, R. 2011. Therapeutic effects of a horse riding simulator in children with cerebral palsy. Arquivos De Neuro-Psiquiatria, 69, 799-804.

CARTA, M. G., MAGGIANI, F., PILUTZU, L., MORO, M. F., MURA, G., CADONI, F., SANCASSIANI, F., VELLANTE, M., MACHADO, S. & PRETI, A. 2014. Sailing for rehabilitation of patients with severe mental disorders: results of a cross over randomized controlled trial. Clin Pract Epidemiol Ment Health, 10, 73-9.

CHANG, Y. K., HUNG, C. L., HUANG, C. J., HATFIELD, B. D. & HUNG, T. M. 2014. Effects of an aquatic exercise program on inhibitory control in children with ADHD: a preliminary study. Arch Clin Neuropsychol, 29, 217-23.

CLARKE, M. L., CLAPHAM, E. D. & SHIM, M. 2020. Sailing as Therapy: Adapted Sailing on Children with Disabilities. Palaestra, 34, 37-43.

COTTERILL, S. T. & BROWN, H. 2018. An exploration of the perceived health, life skill and academic benefits of dinghy sailing for 9-13-year-old school children. Journal of Adventure Education and Outdoor Learning, 18, 227-241.

COUSINS, M. & SMYTH, M. M. 2003. Developmental coordination impairments in adulthood. Human Movement Science, 22, 433-459.

DAVOODY, S., GOESCHL, S., DOLATSHAHI, M., DAVARI-ASHTIANI, R., SAFFARPOUR, R., SODEIFIAN, F. & BRAND, S. 2022. Relation between ADHD and COVID-19: A Narrative Review to Guide Advancing Clinical Research and Therapy. Iran J Psychiatry, 17, 110-117.

D. U. S. C., (DUSC). 2021. Attention Deficit Hyperactivity Disorder:

Utilisation Analysis. In: DHAC (ed.). Pharmaceutical Benefits Scheme (PBS): Drug utilisation sub-committee (DUSC).

ECONOMICS, D. A. 2019. The social and economic costs of ADHD in Australia. Australian ADHD Professionals Association (AADPA)

GIEDD, J. N. & RAPOPORT, J. L. 2010. Structural MRI of pediatric brain development: what have we learned and where are we going? Neuron, 67, 728-34.

GUADAGNOLI, M. A. & LEE, T. D. 2004. Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning. J Mot Behav, 36, 212-24.

HOVE, M. J., ZEFFIRO, T. A., BIEDERMAN, J., LI, Z., SCHMAHMANN, J. & VALERA, E. M. 2015. Postural sway and regional cerebellar volume in adults with attention-deficit/hyperactivity disorder. Neuroimage-Clinical, 8, 422-428.

HOZA, B., SMITH, A. L., SHOULBERG, E. K., LINNEA, K. S., DORSCH, T. E., BLAZO, J. A., ALERDING, C. M. & MCCABE, G. P. 2015. A randomized trial examining the effects of aerobic physical activity on attention-deficit/hyperactivity disorder symptoms in young children. J Abnorm Child Psychol, 43, 655-67.

JANSEN, I., PHILIPSEN, A., DALIN, D., WIESMEIER, I. K. & MAURER, C. 2019. Postural instability in adult ADHD - A pilot study. Gait & Posture, 67, 284-289.

JEOUNG, B. J. 2014. The relationship between attention deficit hyperactivity disorder and health-related physical fitness in university students. Journal of Exercise Rehabilitation, 10, 367-371.

KIM, S. G. & LEE, J. H. 2015. The effects of horse riding simulation exercise on muscle activation and limits of stability in the elderly. Archives of Gerontology and Geriatrics, 60, 62-65.

KIRBY, A., EDWARDS, L., SUGDEN, D. & ROSENBLUM, S. 2010. The development and standardization of the Adult Developmental Co-ordination Disorders/Dyspraxia Checklist (ADC). Res Dev Disabil, 31, 131-9.

LATHAN, C. E., TRACEY, M. R., SEBRECHTS, M. M., CLAWSON, D. M. & HIGGINS, G. A. 2002. Using virtual environments as training simulators: Measuring transfer. Handbook of virtual environments: Design, implementation, and applications, 403-414.

MACKIE, H. W. & LEGG, S. J. 1999. Preliminary assessment of force demands in laser racing. J Sci Med Sport, 2, 78-85.

MARTIN, N. C., PIEK, J. P. & HAY, D. 2006. DCD and ADHD: A genetic study of their shared aetiology. Human Movement Science, 25, 110-124.

MATHIOWETZ, V., WEBER, K., VOLLAND, G. & KASHMAN, N. 1984. Reliability and Validity of Grip and Pinch Strength Evaluations. Journal of Hand Surgery-American Volume, 9a, 222-226.

MERCURIO, L. Y., AMANULLAH, S., GILL, N. & GJELSVIK, A. 2021. Children With ADHD Engage in Less Physical Activity. Journal of Attention Disorders, 25, 1187-1195.

MITANI, Y., DOI, K., YANO, T., SAKAMAKI, E., MUKAI, K., SHINOMIYA, Y. & KIMURA, T. 2008. Effect of exercise using a horse-riding simulator on physical ability of frail seniors. Journal of Physical Therapy Science, 20, 177-183.

MONTALVA-VALENZUELA, F., ANDRADES-RAMIREZ, O. & CASTILLO-PAREDES, A. 2022. Effects of Physical Activity, Exercise and Sport on Executive Function in Young People with Attention Deficit Hyperactivity Disorder: A Systematic Review. European Journal of Investigation in Health Psychology and Education, 12, 61-76.

NEELY, K. A., WANG, P., CHENNAVASIN, A. P., SAMIMY, S., TUCKER, J., MERIDA, A., PEREZ-EDGAR, K. & HUANG-POLLOCK, C. 2017. Deficits in inhibitory force control in young adults with ADHD. Neuropsychologia, 99, 172-178.

PAN, C. Y., CHU, C. H., TSAI, C. L., LO, S. Y., CHENG, Y. W. & LIU, Y. J. 2016. A racket-sport intervention improves behavioral and cognitive performance in children with attention-deficit/hyperactivity disorder. Research in Developmental Disabilities, 57, 1-10.

POLANCZYK, G. & ROHDE, L. A. 2007. Epidemiology of attention-deficit/hyperactivity disorder across the lifespan. Current Opinion in Psychiatry, 20, 386-392.

RECIO, A. C., BECKER, D., MORGAN, M., SAUNDERS, N. R., SCHRAMM, L. P. & MCDONALD, J. W. 2013. Use of a virtual reality physical ride-on sailing simulator as a rehabilitation tool for recreational sports and community reintegration: A pilot study. American Journal of Physical Medicine and Rehabilitation, 92, 1104-1109.

SHAW, P., ECKSTRAND, K., SHARP, W., BLUMENTHAL, J., LERCH, J. P., GREENSTEIN, D., CLASEN, L., EVANS, A., GIEDD, J. & RAPOPORT, J. L. 2007. Attention-deficit/hyperactivity disorder is characterized by a delay in cortical maturation. Proceedings of the National Academy of Sciences of the United States of America, 104, 19649-19654.

SHAW, P., GILLIAM, M., LIVERPOOL, M., WEDDLE, C., MALEK, M., SHARP, W., GREENSTEIN, D., EVANS, A., RAPOPORT, J. & GIEDD, J. 2011. Cortical Development in Typically Developing Children With Symptoms of Hyperactivity and Impulsivity: Support for a Dimensional View of Attention Deficit Hyperactivity Disorder. American Journal of Psychiatry, 168, 143-151.

TENBRINK, T. & DYLLA, F. 2017. Sailing: Cognition, action, communication. Journal of Spatial Information Science, 3-33.

VANCAMPFORT, D., FIRTH, J., SCHUCH, F. B., ROSENBAUM, S., PROBST, M., WARD, P. B., VAN DAMME, T., DE HERT, M. & STUBBS, B. 2016. Dropout from physical activity interventions in children and adolescents with attention deficit hyperactivity disorder: A systematic review and meta-analysis. Mental Health and Physical Activity, 11, 46-52.

WATEMBERG, N., WAISERBERG, N., ZUK, L. & LERMAN-SAGIE, T. 2007. Developmental coordination disorder in children with attention-deficit-hyperactivity disorder and physical therapy intervention. Dev Med Child Neurol, 49, 920-5.

WILENS, T. E., BIEDERMAN, J., FARAONE, S. V., MARTELON, M., WESTERBERG, D. & SPENCER, T. J. 2009. Presenting ADHD Symptoms, Subtypes, and Comorbid Disorders in Clinically Referred Adults With ADHD. Journal of Clinical Psychiatry, 70, 1557-1562.

XIE, Y. T., GAO, X. P., SONG, Y. L., ZHU, X. T., CHEN, M. G., YANG, L. & REN, Y. C. 2021. Effectiveness of Physical Activity Intervention on ADHD Symptoms: A Systematic Review and Meta-Analysis (vol 12, 706625, 2021). Frontiers in Psychiatry, 12.