Leveraging passive exercise to support brain health

Benjamin Tari[1], Matthew Heath[2], Fabian Herold[3], Boris Cheval[4, 5], Flaminia Ronca[6], Jennifer L. Etnier[7], Joseph T. Costello[8], Nicole E. Logan[9], Megan Cully[10], Liye Zou[11]

1. Department of Psychiatry, University of Oxford, Oxford, United Kingdom
2. School of Kinesiology, Western University, London, Canada
3. Research Group Degenerative and Chronic Diseases, Movement, Faculty of Health Sciences Brandenburg, University of Potsdam, Potsdam, Germany
4. Department of Sport Sciences and Physical Education, École normale supérieure de Rennes, Bruz, France
5. VIPS[2] Laboratory, University of Rennes 2, Rennes, France
6. The Institute of Sport, Exercise and Health, Division of Surgery and Interventional Sciences, Faculty of Medical Sciences, University College London, London, United Kingdom
7. Department of Kinesiology, University of North Carolina Greensboro, Greensboro, United States of America
8. School of Psychology, Sport and Health Sciences, University of Portsmouth, Portsmouth, United Kingdom
9. Department of Kinesiology, Interdisciplinary Neuroscience Program, George & Anne Ryan Institute for Neuroscience, College of Health Sciences, University of Rhode Island, Kingston, United States of America
10. Marker AG, Zug, Switzerland.
11. Body-Brain-Mind Laboratory, School of Psychology, Shenzhen University, Shenzhen, China

Corresponding Author:

Professor Liye Zou

School of Psychology
Shenzhen University
518060 Shenzhen, China
liyezou123@gmail.com

Key Words

Passive exercise, cognition, cognitive performance, physical health

Clinicians and practitioners have used passive exercise to improve mobility; however, research designed to systematically explore its effects is not well developed. This editorial will highlight evidence from studies of acute bouts of passive exercise that could be leveraged to understand whether regular passive exercise could maintain and improve brain health.

What is passive exercise? The evidence for current use

Regular active exercise (i.e., volitional aerobic/resistance exercise) has numerous health benefits, including, but not limited to, improved functional abilities (e.g., mobility), reduced risk of developing diseases, improved brain health and cognition, and facilitated recovery following a medical event (e.g., acute injury) [1]. For example, active exercise can improve clinical recovery in individuals with a recent traumatic brain injury and reduce the risk of persistent post-concussive symptoms [2].

For individuals who are unable to actively exercise (e.g., unconscious, paralysed or sedated patients, stroke or spinal cord injury, Parkinson's disease), passive exercise is usually prescribed in settings such as in hospitals, rehabilitation clinics, or care homes [3]. Passive exercise is completed independently of an individual's volitional effort and relies entirely on an external force to move an individual's limbs. In this framework, passive exercise involves movement through a specified range of motion, often via therapist-assisted movement and/or via a mechanically driven flywheel or stationary tandem bicycle. In this context, the overarching goal of passive exercise is to maintain or improve mobility and prevent further musculoskeletal complications. However, the specific promotion of brain health via passive exercise prescription is often overlooked.

Promising early research from Ridgel and colleagues [4] reported that passive exercise provides a benefit to cognitive function in individuals with Parkinson's disease. However, there have since been few further advancements in the field. The role of passive exercise in supporting, maintaining, or improving brain health remains underappreciated and its potential benefits on brain health remain to be fully explored. Further investigation on the influence of passive exercise might open new avenues to support the brain health of individuals with certain medical conditions, as well as of those who find it challenging to engage in structured active exercise. For these populations, preserving or improving brain health through passive exercise might result in better overall health.

Passive exercise improves brain health

In previous work, passive exercise performed via a mechanically driven cycle ergometer flywheel improved the executive function (EF) component of cognition (assessed via an inhibitory control task) for ~30-min following exercise cessation in young adults [5, 6]. Furthermore, passive exercise buffered the negative effects of a mentally fatiguing task (the psychomotor vigilance task) [7] and provided a benefit even when performed concurrently with an EF task [8]. The latter result is particularly noteworthy because it diverges from previously documented effects of active exercise [9], and intimates that passive exercise does not entail dual-task cognitive demands. As a result, passive exercise looks to support increased cognitive (attentional) performance to support high-level EF demands. Furthermore, passive exercise using muscle stimulation — via lower calf muscle pump activation and whole-body vibration — reversed cognitive impairment and regulated blood pressure in hypotensive elderly adults, and improved EF, including inhibitory control, in healthy young adults [10, 11]. It has been

previously hypothesised that these benefits are related to a passive exercise-induced increase in cerebral blood flow related to the activation of mechanoreceptive muscle afferent feedback that stimulates the activity of primary and somatosensory cortices to increase stroke volume and cardiac output [5]. However, other potential mechanisms should be investigated in future studies (Figure 1).

Acute bouts of passive exercise elicit postexercise cognitive benefits similar to those of active aerobic exercise, without intense metabolic and cardiorespiratory demands [5], and provide cognitive benefits during exercise that are distinct from those demonstrated with active exercise [8]. These findings provide an intriguing framework for evaluating how regular passive exercise may support brain health in individuals who are unable to engage in active exercise, as well as in healthy individuals.

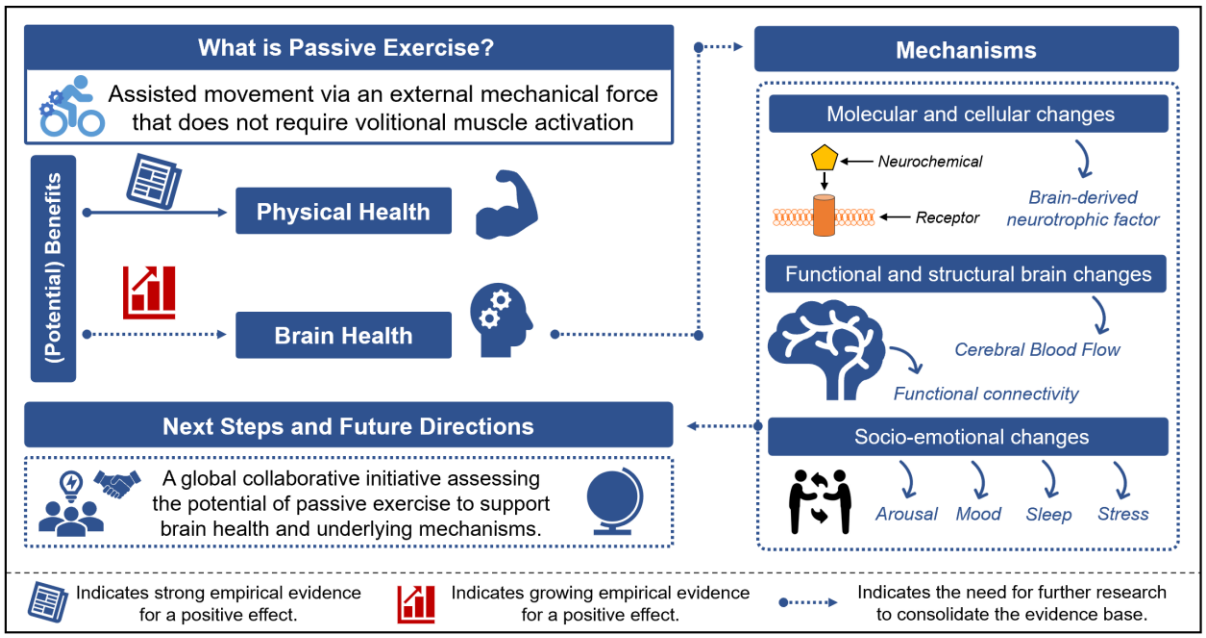

Figure 1. Graphical representation of the definition of passive exercise, its benefits, potential mechanisms and potential next steps.

The next steps: Multiple populations may benefit from passive exercise

Passive exercise may serve as an effective adjunct treatment for individuals who are no longer able to safely or confidently access/perform exercise independently, including those with mobility issues, and behavioural, psychiatric, or neurodegenerative disorders. For these individuals, regular passive exercise may serve as a means to support functional abilities and slowly reintroduce active exercise. Furthermore, this modality might be effectively leveraged in the daily lives of healthy individuals with restricted mobility to support brain health (e.g., passive exercise during sedentary activities: office/schoolwork, video gaming, watching television). Although this is not an exhaustive list, it presents several promising research streams that could prove impactful and should be prioritised in future projects.

The investigation of acute and regular passive exercise will also serve as a platform to better understand the mechanisms by which active exercise improves cognition. For example, experiments that examine passive exercise by assessing changes to lactate, catecholamine and neurotrophin concentrations, rates of cerebral blood flow, and/or neural activation will allow

us to recognise passive exercise's impact on brain health. These results may have implications for both healthy and chronically ill or impaired individuals.

Exploring the potential of passive exercise

It should not be expected that either acute or regular bouts of passive exercise will replace active exercise; rather, it will be a salutary adjunct for those who are otherwise unable to fully participate in the latter. For example, passive exercise may be integrated into treatment plans designed to meet the specific needs of patients.

Although there is extensive evidence for its utility in physical rehabilitation [3], the effects of passive exercise on brain health remain understudied. In this context, regular long-term passive exercise may be an approach, among others, to preserve brain health alongside functional abilities. Optimally, passive exercise may also prolong the health span of an individual by reducing or delaying disease progression. In prompting future research directions, we propose additional mechanistic studies, as well as the investigation of passive exercise in multi-lab "mega studies" [12]. This will allow us to robustly identify effects and perform subgroup analyses to understand the influence of different moderators (e.g., personal factors such as age, biological sex, disease types, socioeconomic status, and racial groups) and potential mediators (Figure 1).

We recognise that implementing passive exercise in real-world settings can face several challenges that need to be addressed, including its effectiveness compared to active exercise, equipment costs and quality, recruitment, motivation, and adherence issues, as well as safety concerns for certain health conditions.

Overall, however, we believe that passive exercise may be a powerful but underutilised complementary exercise modality to promote and preserve brain health. We advocate additional research in this field and on the mechanisms that underpin these putative benefits.

Acknowledgements

We would like to acknowledge and thank all our colleagues who provided informative comments in shaping this editorial.

Conflicts of Interest

The authors declare no conflicts of interest.

References

1. World Health Organization. Global status report on physical activity 2022. Geneva: World Health Organization; 2022
2. Leddy JJ, Master CL, Mannix R, et al. Early targeted heart rate aerobic exercise versus placebo stretching for sport-related concussion in adolescents: a randomised controlled trial. Lancet Child Adoles Health 2021;5:792–799. doi:10.1016/S2352-4642(21)00267-4
3. Trinity JD, Richardson RS. Physiological Impact and Clinical Relevance of Passive Exercise/Movement. Sports Med 2019;49:1365–1381. doi:10.1007/s40279-019-01146-1
4. Ridgel AL, Kim CH, Fickes EJ, et al. Changes in executive function after acute bouts of passive cycling in Parkinson's disease. J Aging Phys Act 2011;19:87–98. https://doi.org/10.1123/japa.19.2.87
5. Shirzad M, Tari B, Dalton C, et al. Passive exercise increases cerebral blood flow velocity and supports a postexercise executive function benefit. Psychophysiology 2022;59:e14132. doi:10.1111/psyp.14132
6. Tari B, Ahn J, Dalton C, et al. Cerebral blood flow and immediate and sustained executive function benefits following single bouts of passive and active exercise. Brain Cogn 2023;166:105953. doi:10.1016/j.bandc.2023.105953
7. Ahn J, Tari B, Morava A, et al. A single bout of passive exercise mitigates a mental fatigue-induced inhibitory control deficit. Exp Brain Res 2023;241:1835–1845. doi:10.1007/s00221-023-06640-7
8. Dalton C, Edgar C, Tari B, et al. Passive exercise provides a simultaneous and postexercise executive function benefit. Front Cognit 2024;3: doi:10.3389/fcogn.2024.1334258
9. Zheng K, Zou L, Wei G, et al. Concurrent performance of executive function during acute bouts of exercise in adults: A systematic review. Brain Sci 2021;11:1364. doi:10.3390/brainsci11101364
10. McLeod KJ, Stromhaug A. Reversal of cognitive impairment in a hypotensive elderly population using a passive exercise intervention. Clin Interv Aging 2017;12:1859–1866. doi:10.2147/CIA.S147959
11. Regterschot GR, Van Heuvelen MJ, Zeinstra EB, et al. Whole body vibration improves cognition in healthy young adults. PloS One 2014;9:e100506. doi:10.1371/journal.pone.0100506
12. Milkman KL, Gromet D, Ho H, et al. Megastudies improve the impact of applied behavioural science. Nature 2021;600:478–483. doi:10.1038/s41586-021-04128-4