Journal of Statistics on Health Decision

Technology-mediated intervention and cognitive functioning: a systematic review and meta-analysis

Pollyanna Stefane[1,2,3], Vera Afreixo[4,5], Oscar Ribeiro[1,3], Anabela G. Silva[3,6]

[1]Department of Education and Psychology, University of Aveiro, Aveiro, Portugal
[2]Abel Salazar Institute of Biomedical Sciences, University of Porto, Porto, Portugal
[3]Center for Health Technology and Services Research (CINTESIS@RISE)
[4]Center for Research & Development in Mathematics and Applications (CIDMA)
[5]Department of Mathematics, University of Aveiro, Aveiro, Portugal
[6]School of Health Sciences, University of Aveiro, Aveiro, Portugal

Introduction:

Mild cognitive impairment (MCI) is usually defined as an early stage of cognitive decline with a risk of progressing to Alzheimer's disease or dementia[1, 2]. Interventions to prevent MCI as well as to delay its progression are important. Research has shown a significant and consistent protective effect for all levels of physical activity against the occurrence of cognitive decline [3-5]. Despite evidence on the benefits of physical activity, a recent study has shown that only 55,5% of the European older adults meet WHO's recommendations, and older adults with MCI presented higher odds of not performing this recommended level of physical activity [6, 7]. Identifying pleasant ways of performing physical activity might help them achieve the recommended levels. A potentially attractive way of performing physical activity is through technology. There are several types of physical activity activities that are mediated by technology, including sports [8-10] or dancing [11-14]. These activities are believed to require both physical and cognitive abilities and have been used to improve physical and cognitive functions in older adults [15-17]. To our knowledge there is no systematic review that aimed at synthetizing and evaluating existing evidence on the impact of technology-mediated physical activity on cognitive functioning of older adults with clinical conditions, therefore this study aims to assess the impact of technology-mediated physical activity on the cognitive function of older adults with clinical conditions.

Methods:

The literature search was carried out independently by one of the authors. Four databases (PubMed, SCOPUS, SciELO and Web of Science) were searched using a combination of words related to interventions mediated by technology, physical exercise, and older adults. There were no restrictions on date of publication. We included studies published in English, Portuguese, and Spanish languages, randomized or quasi-randomized clinical trials, including participants 55 years or older with no to mild cognitive impairment.

Risk of bias of the included studies was assessed using Rob 2 [18], and quality of evidence was assessed using the GRADE [19].

A meta-analysis was performed using R packages meta and metafor in RStudio Version 1.4.1103 (Rstudio Team, 2020) running R version 4.0.5 (R Core Team, 2021). As cognitive function was measured on different scales, the standardized mean difference (SMD) was used to measure the effect size. Heterogeneity was evaluated using I2 statistic that ranges from 0 to 100%, which reflect low (25%), moderate (50%), and high (75%) statistical heterogeneity [20]. A random-effect model was used, and forest plots were used to present the SMD.

Cognitive function was classified into six domains, (1) general cognition (2) immediate verbal memory, (3) delayed verbal memory, (4) working memory, (5) attention, and (6) inhibition.

Results:

Eight studies were included in this systematic review [10, 15, 21-26]. Of these, five studies assessed general cognition [15, 21, 23-25], three assessed immediate verbal memory [15, 23, 26], three assessed delayed verbal memory [15, 23, 26], two assessed working memory [10, 26], three assessed attention [22, 23, 26], and two assessed inhibition [23, 26]. Very low quality of evidence indicates that the intervention mediated by technology was superior to combined exercise (cognitive + physical activity) [15, 23] and traditional physical exercise [26] for delayed verbal memory (SDM 0.42, 95% CI 0.01 – 0.83, p=0.04, I2=

Keywords:
Technology; older adults; cognition.

Corresponding author:
Pollyanna Stefane,
pslimas@ua.pt

Conflict of interest:
There are no conflicts of interest.

Clinical study registration number: XXXXXXXX

First published: 20JUL2022

0%, p=0.47). For the remaining comparisons no difference was found between the technology intervention and traditional physical exercise [21, 22, 24, 26], combined exercise [15, 23], and receiving a booklet with information and illustration outlining the benefits and risks of physical activities [25].

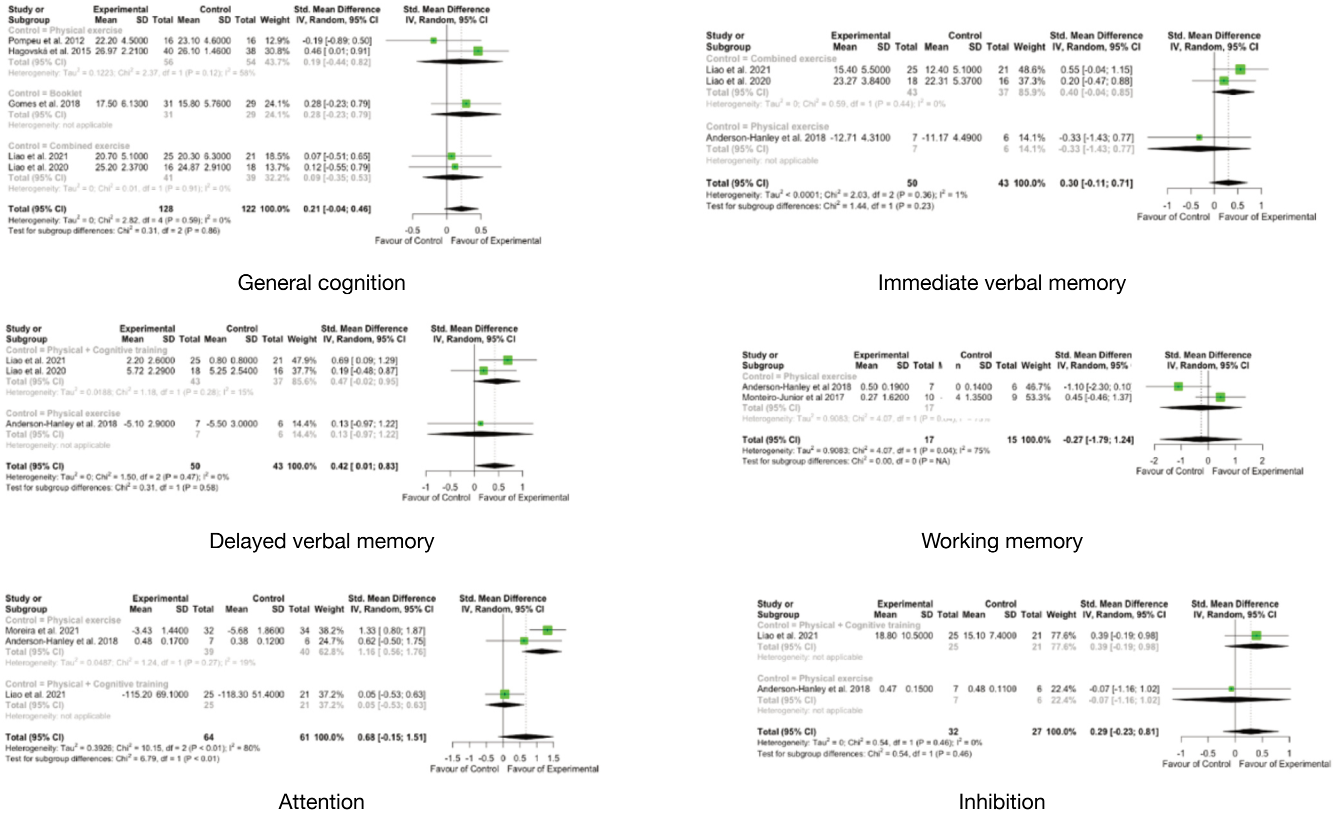

Figure 1 - Metanalysis of cognitive function for older adults with clinical conditions

Discussion:

Results suggest no difference between interventions mediated by technology and the other interventions (i.e. physical exercise and combined physical and cognitive exercise) on the cognition of older adults with clinical conditions. The small sample size of the studies, and the diversity of the design of the included studies, which vary in duration of the intervention, number of sessions, duration of session, and interventions used can explain the obtained results. For the result presented in delayed verbal memory, it might be due to the pattern of the interventions. In all studies that assessed this domain included greater demand on the cognitive component (such as X-box, VR bicycle), and in the control group, one of the studies [23], the authors did not include a cognitive component, and in the other (26), the cognitive component was of very low demand (virtual scenic bike tour: physical exercise interactive with relatively passive and low cognitive load).

In conclusion, very low quality of evidence indicates no difference between intervention mediated by technology and the other intervention in cognition of older adults with clinical conditions. The first limitation of this meta-analysis is the methodological quality of the included studies, which presented high risk of bias, and the second one is the heterogeneity of the studies. Given the potential benefits of interventions mediated by technology, more research is needed to establish the effective components for cognition and physical function and apply this understanding to the development of evidence-based interventions and stablished guidelines for the best prevention or treatment of cognitive decline.

Acknowledgements:

Grant number: UI/BD/151503/2021

References:

1. Winblad B, Palmer K, Kivipelto M, Jelic V, Fratiglioni L, Wahlund LO, et al. Mild cognitive impairment--beyond controversies, towards a consensus: report of the International Working Group on Mild Cognitive Impairment. J Intern Med. 2004;256(3):240-6. https://doi.org/10.1111/j.1365-2796.2004.01380.x
2. Petersen RC, Smith GE, Waring SC, Ivnik RJ, Tangalos EG, Kokmen E. Mild cognitive impairment: clinical characterization and outcome. Arch Neurol. 1999;56(3):303-8. https://doi.org/10.1001/archneur.56.3.303

3. Livingston G, Sommerlad A, Orgeta V, Costafreda SG, Huntley J, Ames D, et al. Dementia prevention, intervention, and care. The Lancet. 2017;390(10113):2673-734. https://doi.org/10.1016/S0140-6736(17)31363-6
4. Sofi F, Valecchi D, Bacci D, Abbate R, Gensini GF, Casini A, et al. Physical activity and risk of cognitive decline: a meta-analysis of prospective studies. J Intern Med. 2011;269(1):107-17. https://doi.org/10.1111/j.1365-2796.2010.02281.x
5. Falck RS, Davis JC, Liu-Ambrose T. What is the association between sedentary behaviour and cognitive function? A systematic review. Br J Sports Med. 2017;51(10):800-11. https://doi.org/10.1136/bjsports-2015-095551
6. Clemente Remon AL, Jimenez Diaz-Benito V, Jimenez Beatty JE, Santacruz Lozano JA. Levels of Physical Activity Among Older Adults in the European Union. J Aging Phys Act. 2020;29(2):242-9. https://doi.org/10.1123/japa.2020-0177
7. Vancampfort D, Stubbs B, Lara E, Vandenbulcke M, Swinnen N, Koyanagi A. Mild cognitive impairment and physical activity in the general population: Findings from six low- and middle-income countries. Exp Gerontol. 2017;100:100-5. https://doi.org/10.1016/j.exger.2017.10.028
8. López-García J, Colado JC, Guzmán JF. Acute Effects of Aerobic Exercise and Active Videogames on Cognitive Flexibility, Reaction Time, and Perceived Exertion in Older Adults. Games Health J. 2019;8(6):371-9. https://doi.org/10.1089/g4h.2018.0143
9. Maillot P, Perrot A, Hartley A. Effects of interactive physical-activity video-game training on physical and cognitive function in older adults. Psychol Aging. 2012;27(3):589-600. https://doi.org/10.1037/a0026268
10. Monteiro-Junior RS, da Silva Figueiredo LF, Maciel-Pinheiro PT, Abud ELR, Braga AEMM, Barca ML, et al. Acute effects of exergames on cognitive function of institutionalized older persons: a single-blinded, randomized and controlled pilot study. Aging Clin Exp Res. 2017;29(3):387-94. https://doi.org/10.1007/s40520-016-0595-5
11. Eggenberger P, Schumacher V, Angst M, Theill N, de Bruin ED. Does multicomponent physical exercise with simultaneous cognitive training boost cognitive performance in older adults? A 6-month randomized controlled trial with a 1-year follow-up. Clin Interv Aging. 2015;10:1335-49. https://doi.org/10.2147/CIA.S87732
12. Pichierri G, Coppe A, Lorenzetti S, Murer K, de Bruin ED. The effect of a cognitive-motor intervention on voluntary step execution under single and dual task conditions in older adults: a randomized controlled pilot study. Clin Interv Aging. 2012;7:175-84. https://doi.org/10.2147/CIA.S32558
13. Pichierri G, Murer K, de Bruin ED. A cognitive-motor intervention using a dance video game to enhance foot placement accuracy and gait under dual task conditions in older adults: a randomized controlled trial. BMC Geriatr. 2012;12:74. https://doi.org/10.1186/1471-2318-12-74
14. Schoene D, Valenzuela T, Toson B, Delbaere K, Severino C, Garcia J, et al. Interactive Cognitive-Motor Step Training Improves Cognitive Risk Factors of Falling in Older Adults - A Randomized Controlled Trial. PLoS ONE. 2015;10(12):e0145161. https://doi.org/10.1371/journal.pone.0145161
15. Liao YY, Tseng HY, Lin YJ, Wang CJ, Hsu WC. Using virtual reality-based training to improve cognitive function, instrumental activities of daily living and neural efficiency in older adults with mild cognitive impairment. European Journal of Physical and Rehabilitation Medicine. 2020;56(1):47-57. https://doi.org/10.23736/S1973-9087.19.05899-4
16. Costa LV, Veloso AI, Loizou M, Arnab S. Games for active ageing, well-being and quality of life: a pilot study. Behaviour & Information Technology. 2018;37(8):842-54. https://doi.org/10.1080/0144929X.2018.1485744
17. Swinnen N, Vandenbulcke M, Vancampfort D. Exergames in people with major neurocognitive disorder: a systematic review. DISABILITY AND REHABILITATION-ASSISTIVE TECHNOLOGY. 2020. https://doi.org/10.1080/17483107.2020.1785566
18. Higgins JP, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ. 2011;343:d5928. https://doi.org/10.1136/bmj.d5928
19. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. Bmj. 2008;336(7650):924-6. https://doi.org/10.1136/bmj.39489.470347.AD
20. Dwivedi SN. Which is the Preferred Measure of Heterogeneity in Meta-Analysis and Why? A Revisit. Biostatistics and Biometrics Open Access Journal. 2017;1(1). https://doi.org/10.19080/BBOAJ.2017.01.555555
21. Pompeu JE, Mendes FADS, Silva KGD, Lobo AM, Oliveira TDP, Zomignani AP, et al. Effect of Nintendo Wii™Based motor and cognitive training on activities of daily living in patients with Parkinson's disease: A randomised clinical trial. Physiotherapy (United Kingdom). 2012;98(3):196-204. https://doi.org/10.1016/j.physio.2012.06.004
22. Moreira NB, Rodacki ALF, Costa SN, Pitta A, Bento PCB. Perceptive-Cognitive and Physical Function in Prefrail Older Adults: Exergaming Versus Traditional Multicomponent Training. REJUVENATION RESEARCH. 2021;24(1):28-36. https://doi.org/10.1089/rej.2020.2302
23. Liao YY, Chen IH, Hsu WC, Tseng HY, Wang RY. Effect of exergaming versus combined exercise on cognitive function and brain activation in frail older adults: A randomised controlled trial. Annals of Physical and Rehabilitation Medicine. 2021;64(5). https://doi.org/10.1016/j.rehab.2021.101492
24. Hagovská M, Olekszyová Z. Impact of the combination of cognitive and balance training on gait, fear and risk of falling and quality of life in seniors with mild cognitive impairment. Geriatr Gerontol Int. 2016;16(9):1043-50. https://doi.org/10.1111/ggi.12593
25. Gomes GCV, Simoes MDS, Lin SM, Bacha JMR, Viveiro LAP, Varise EM, et al. Feasibility, safety, acceptability, and functional outcomes of playing Nintendo Wii Fit Plus(TM) for frail older adults: A randomized feasibility clinical trial. Maturitas. 2018;118:20-8. https://doi.org/10.1016/j.maturitas.2018.10.002
26. Anderson-Hanley C, Barcelos NM, Zimmerman EA, Gillen RW, Dunnam M, Cohen BD, et al. The Aerobic and Cognitive Exercise Study (ACES) for community-dwelling older adults with or at-risk for mild cognitive impairment (MCI): Neuropsychological, neurobiological and neuroimaging outcomes of a randomized clinical trial. Front Aging Neurosci. 2018;10(MAY). https://doi.org/10.3389/fnagi.2018.00076