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The Impact of Physical Activity on Working Memory Performance in the Aging Population

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INTRODUCTION

Relevance of the Topic

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1. Working memory (WM) - **essential** component **of higher cognitive functioning**
2. WM performance **declines with increasing age**
3. **Physical activities** (PA) are positively related to **better WM** performance
   - in both healthy older adults and in those with mild cognitive impairment or Alzheimer`s disease
4. But… these studies usually investigate **physical exercise** and **not overall physical activity** of an individual

(Baddeley, 2003; Chang et al., 2013; Deng et al., 2024; D'Antuono et al., 2022; Kirova et al., 2015; Pauls et al., 2013; Peich et al., 2013; Zhidong et al., 2021)

Aim of this study

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to investigate the relationship **between a broader spectrum of physical activities (PA) and WM performance**, particularly in the context of aging, by comparing the effects of PA performed over a **lifetime** to those done in the **past year**

Working memory (1)

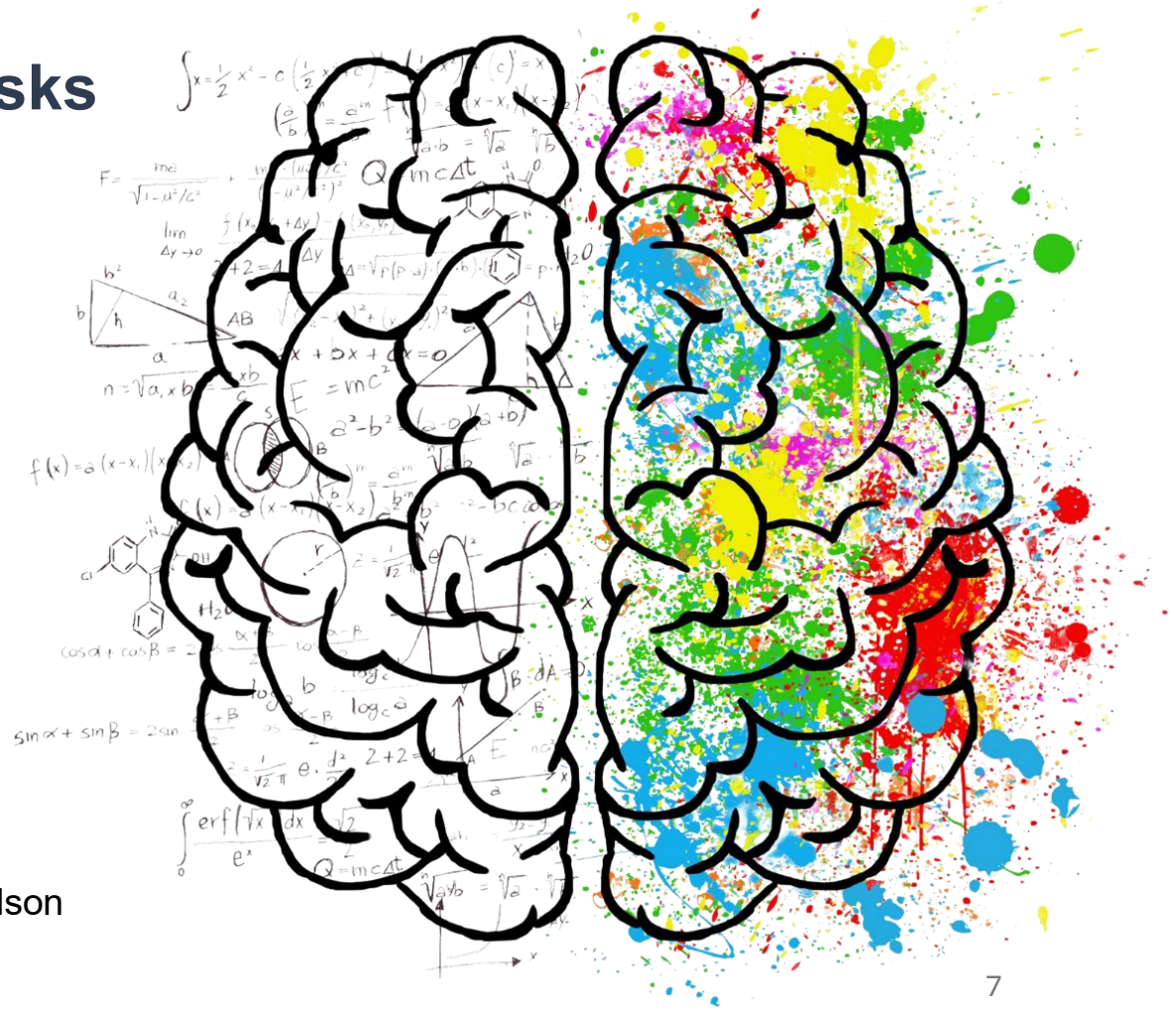
A **limited-capacity,** interconnected system of cognitive processes in the brain that enables the **temporary storage** and **manipulation of information** for performing complex cognitive tasks

(Baddeley et al., 2011)

Working memory (2)

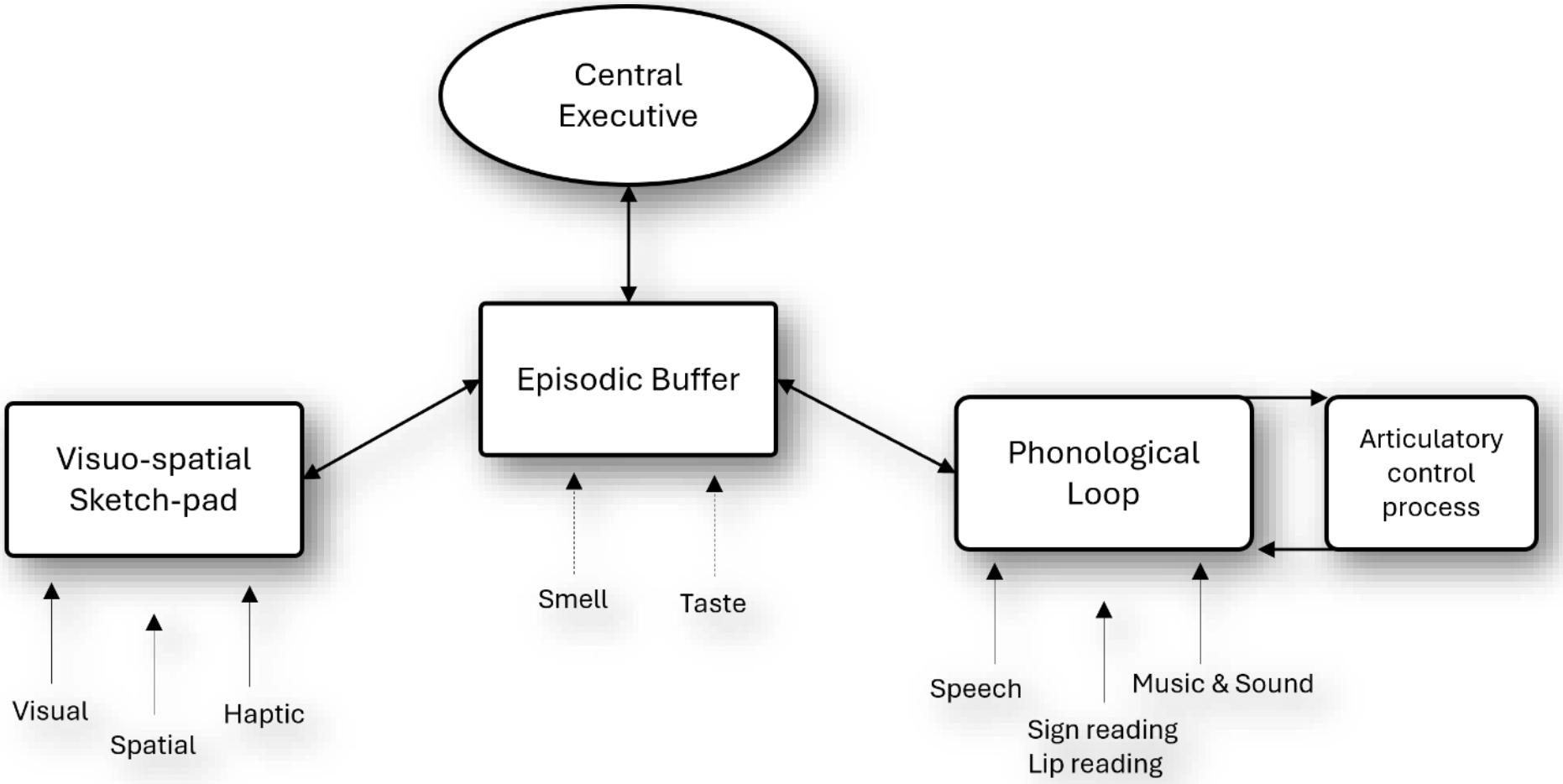
… for performing **complex cognitive tasks**

- reasoning,
- planning,
- problem-solving,
- decision-making,
- language,
- abstract thinking,
- complex social behavior
- social cognition



(Diamond, 2013; Levy, 2024; Nelson et al., 2015; Nickel & Gu, 2018)

Multicomponent model of WM



(Baddeley et al., 2011)

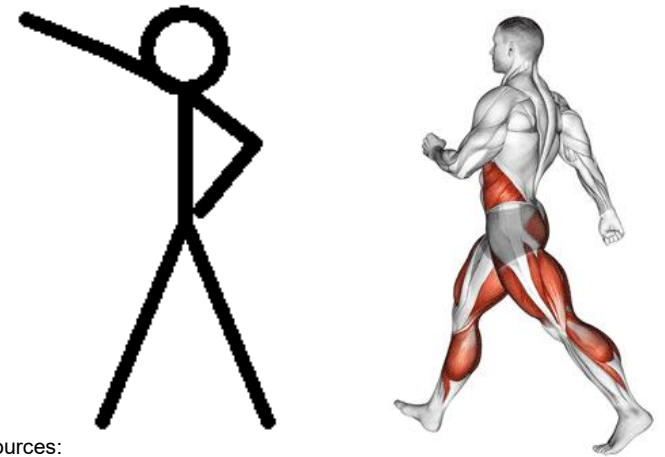
Physical activities

- **Any bodily movement** produced by skeletal **muscles** that results in **energy expenditure**

(Caspersen et al., 1985)

- Any bodily movement that increases energy expenditure **above the resting level**

(Malm et al., 2019)



Picture sources:
https://www.pinterest.com/pin/cardio-exercises--864972672152436900/
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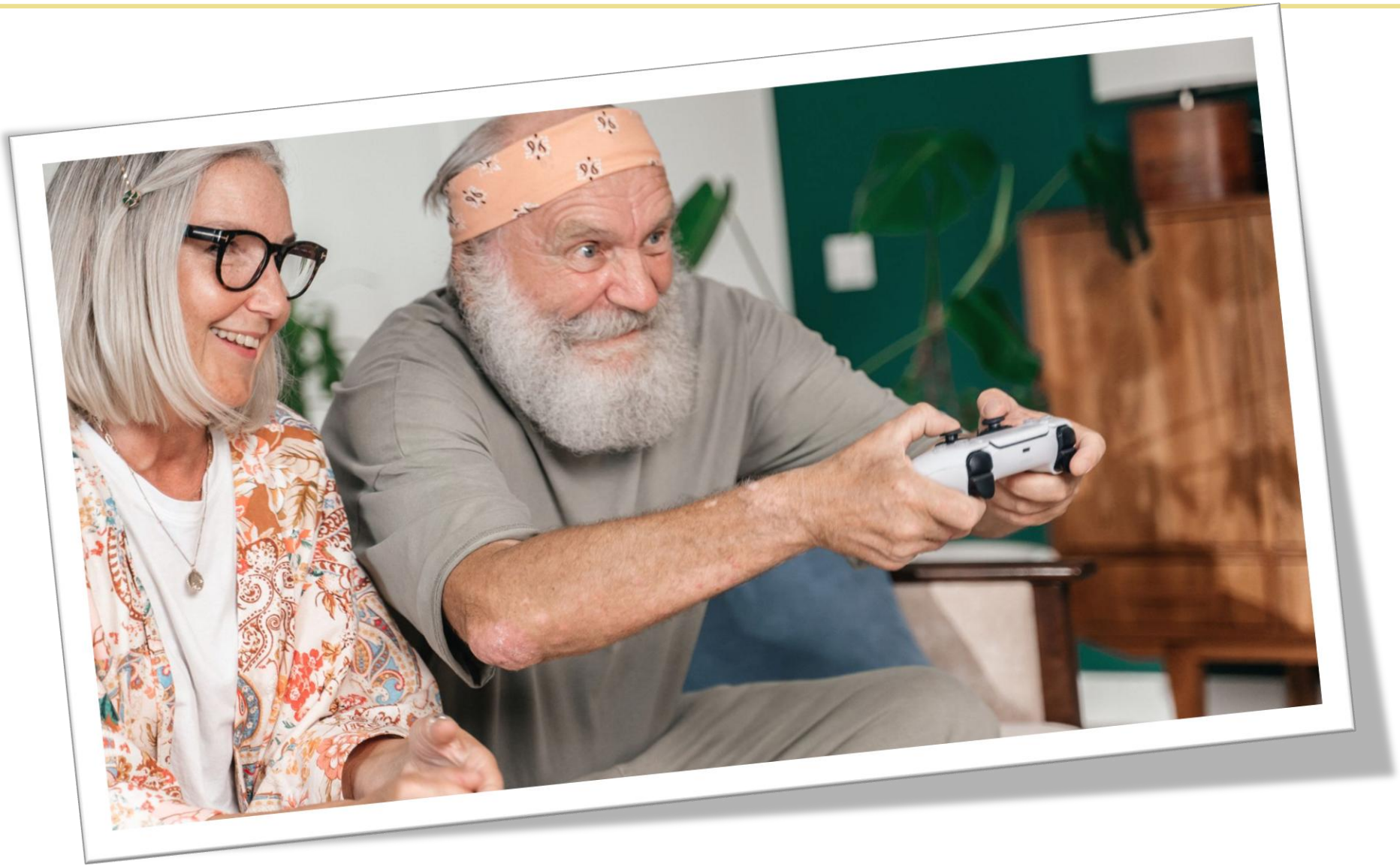
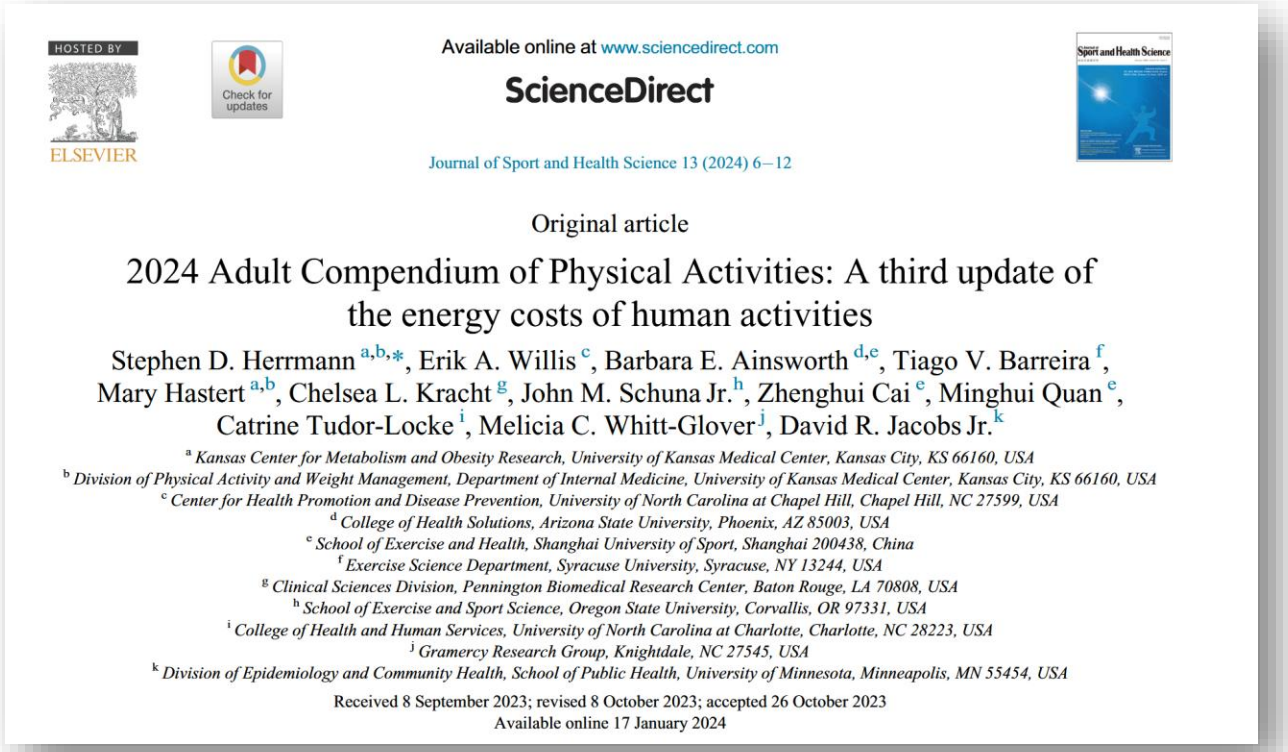
Types of physical activities

Types of physical activities

Types of physical activities



Types of physical activities



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Original article

2024 Adult Compendium of Physical Activities: A third update of the energy costs of human activities

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- 22 major **physical activity (PA) groups**
- **<u>1114</u>** physical activities

(Herrmann et al., 2024)

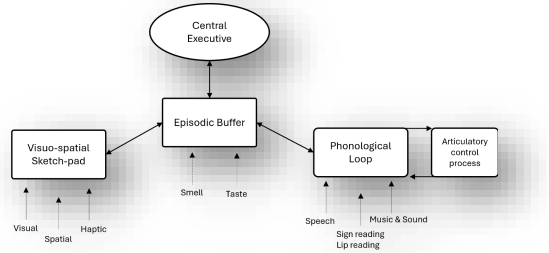
Types of physical activities

No.	Physical Activity Group	Examples
1.	**Bicycling**	*Mountain/leisure cycling, commuting to/from work*
2.	**Walking**	*Hiking, climbing stairs, leisure walking*
3.	**Conditioning Exercise**	*Weightlifting, yoga, therapeutic exercise*
4.	**Music playing**	*Accordion, drums, guitar, trumpet*
5.	**Water activities**	*Swimming, surfing, water volleyball*
6.	**Dancing**	*Ballet, folk dance, salsa, tango*
7.	**Occupation**	*Bakery, heavy lifting, firefighter*
8.	**Winter Activities**	*Skiing, mountain climbing, snow shoveling*
9.	**Hunting & fishing**	*Fishing, duck hunting, sitting/standing in a boat*
10.	**Running**	*Slow running, marathon, triathlon*
11.	**Religious activities**	*Ceremonies, prayers, pilgrimage*
12.	**Home & garden**	*Floor cleaning, dusting, cooking*
13.	**Self-care**	*Washing, dressing, hair styling, shaving*
14.	**Volunteering**	*Walking, sitting, babysitting/animal care*
15.	**Home renovations**	*Carpentry, wallpapering, painting*
16.	**Sexual activities**	*Active, passive (kissing), moderately active*
17.	**Video games**	*VR standing/sitting, active or passive playing*
18.	**Sports**	*Hockey, boxing, football, basketball, billiards*
19.	**Gardening**	*Sand digging, lawn mowing, watering*
20.	**Transportation**	*Driving a car, motorcycle, airplane, rickshaw*
21.	**Inactivity**	*Watching TV, meditating, sleeping, phone*
22.	**Miscellaneous**	*Card games, laughing, handicrafts, computer work*

(Herrmann et al., 2024)

WM & PA

1. Bicycling
2. Walking
3. Occupational
4. Gardening
5. …
6. …
7. …



METHODS

Participants

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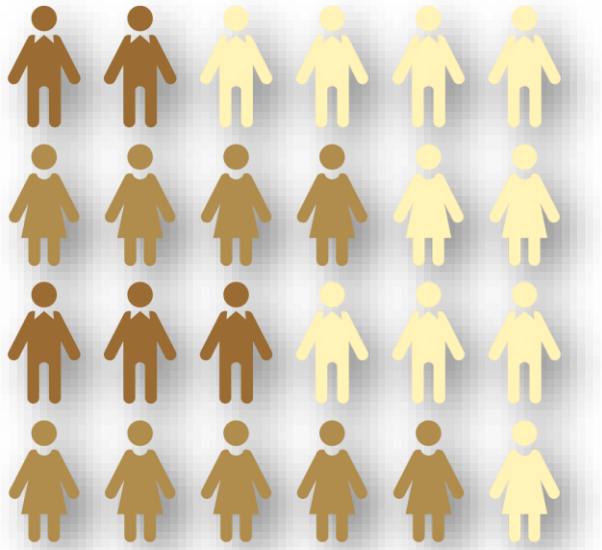
N = 54

- M_{age} = 68.15; SD = 6.87
- 35% male (n = 19), 65% female (n = 35)
- 63% of participants had a MoCA score ≤ 25 (n = 34)
- 37% of participants had a MoCA score ≥ 26 (n = 20)



Assessment tools

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Physical activities

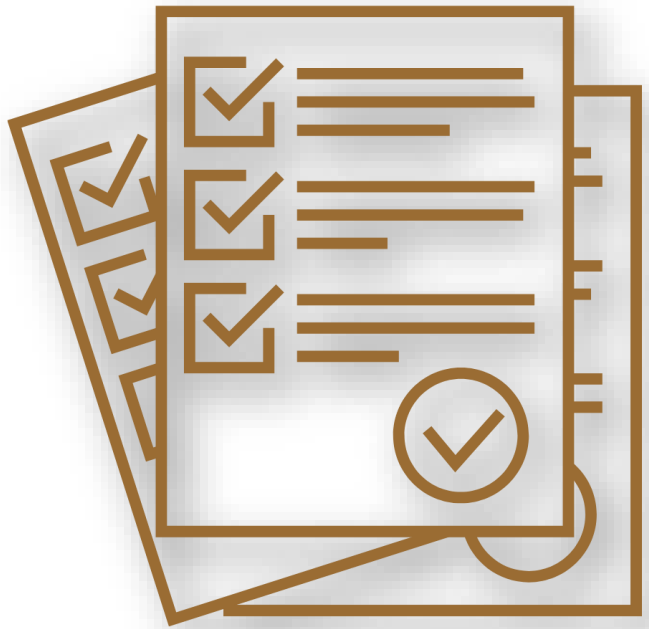
- During lifetime – Motor Reserve Index Questionnaire (MRIq)
- During the past year – Current Physical Activity Questionnaire (CPAq)

Working memory

- Corsi Block-Tapping Task (CBTT)
- Backward Corsi Block-Tapping Task (Backwards CBTT)
- N-Back (2-back) Task

Additionally

- Montreal Cognitive Assessment (MoCA)



MRIq & CPAq

- **Semi-structured interviews**
- Both questionnaires comprise 17 items covering **six areas**:
  - *Housework activities*
  - *Walking activities*
  - *Leisure activities*
  - *Physical exercising*
  - *Care activities*
  - *Workplace activities*
- **MRIq** – assesses physical activity (PA) frequency **since the age of 18**
- **CPAq** – assesses physical activity (PA) frequency during the **past 12 months**

(Pucci, 2024; Pucci et al., 2024)

RESULTS

Internal validity of MRIq & CPAq

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Activity Categories (items)	Cronbach`s alpha	
	MRIq (physical activities during a lifetime), N=37	CPAq (physical activities during last 12 months), N=45
Housework activities (3 questions)	0,627	0.596
Walking activities (3 questions)	0,706	0.583
Leisure activities (2 questions)	0,617	0.17
Physical exercising (2 questions)	0,866	0.508
Care activities (2 questions)	0,004	0.319
Workplace activities (5 questions)	0,545	0.54
Total	**0,806**	**0,577**
The Cronbach`s alpha coefficient calculated by the authors of the original version of the questionnaire	0,83	0,54

The low Cronbach's alpha values for the CPAq reflect not so much low internal consistency, but rather individual differences in physical activity over the past year, as opposed to across the entire lifespan

Lifetime PA & WM

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Partial Spearman correlation between MRIq and WM

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. CBTT	—												
2. Backwards CBTT	0.497***	—											
3. Accuracy in the 1-back condition (N-Back)	-0.097	0.02	—										
4. Average reaction time in 1-back condition (N-Back)	0.069	0.041	-0.668***	—									
5. Accuracy in the 2-back condition (N-Back)	0.028	0.154	0.423**	-0.236	—								
6. Average reaction time in 2-back condition (N-Back)	-0.061	-0.12	-0.358**	0.578***	-0.18	—							
7. MRIq Household activities	-0.079	-0.04	0.06	-0.096	0.114	0.102	—						
8. MRIq Walking	0.141	0.05	0.162	-0.192	0.088	-0.085	0.062	—					
9. MRIq Leisure-time activities	-0.113	-0.08	0.05	-0.067	-0.13	-0.03	0.255	-0.267	—				
10. MRIq Sports activities	0.148	-0.12	-0.094	0.144	0.056	0.032	-0.158	0.362**	-0.006	—			
11. MRIq Caregiving	0.004	-0.05	-0.088	0.065	0.128	-0.039	-0.057	-0.026	0.079	0.064	—		
12. MRIq Work activities	0.215	0.15	0.052	-0.129	-0.01	-0.390**	0.165	0.219	0.226	0.092	0.2	—	
13. MRIq Total score	0.081	-0.05	0.052	-0.068	0.113	-0.134	0.365**	0.246	0.591***	0.511***	0.346*	0.594***	—

Note. controlling for ' Age, years' and 'MoCA score'

Note. * p < .05, ** p < .01, *** p < .001

Last year PA & WM

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Partial Spearman correlation between CPAq and WM

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. CBTT	—												
2. Backwards CBTT	0.469***	—											
3. Accuracy in the 1-back condition (N-Back)	-0.046	0.069	—										
4. Average reaction time in 1-back condition (N-Back)	0.078	0.016	-0.636***	—									
5. Accuracy in the 2-back condition (N-Back)	-0.035	0.083	0.598***	-0.312*	—								
6. Average reaction time in 2-back condition (N-Back)	-0.078	-0.05	-0.453***	0.520***	-0.18	—							
7. CPAq Household activities	-0.127	-0.13	0.04	0.047	0.067	0.155	—						
8. CPAq Walking	-0.189	-0.23	0.450**	-0.165	0.237	-0.15	0.235	—					
9. CPAq Leisure-time activities	0.047	0.118	-0.147	0.064	-0.03	0.211	0.246	-0.147	—				
10. CPAq Sports activities	-0.208	0.008	0.205	-0.12	-0.02	-0.21	-0.002	0.198	-0.028	—			
11. CPAq Caregiving	-0.046	-0.08	0.024	-0.1	-0.02	0.145	0.298*	0.163	0.290*	-0.204	—		
12. CPAq Work activities	-0.087	-0.18	0.084	-0.084	0.186	-0.04	0.097	0.197	0.089	0.141	-0.021	—	
13. CPAq Total score	-0.202	-0.17	0.207	-0.121	0.15	0.022	0.581***	0.508***	0.448***	0.388**	0.447***	0.613***	—

Note. controlling for ' Age, years' and 'MoCA score'

Note. * p < .05, ** p < .01, *** p < .001

Associations

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		Visuospatial WM/Episodic buffer		Central executive / whole WM system			
		CBBT	Backwards CBTT	Accuracy in the 1-back condition (N-Back)	Accuracy in the 2-back condition (N-Back)	Reaction time in 1-back condition (N-Back)	Reaction time in 2-back condition (N-Back)
Last 12 months	CPAq Household activities	-	-	-	-	-	-
	CPAq Walking	-	-	r = 0.45, p<0.01	-	-	-
	CPAq Leisure-time activities	-	-	-	-	-	-
	CPAq Sports activities	-	-	-	-	-	-
	CPAq Caregiving	-	-	-	-	-	-
	CPAq Work activities	-	-	-	-	-	-
	CPAq Total score	-	-	-	-	-	-
Lifetime	MRIq Household activities	-	-	-	-	-	-
	MRIq Walking	-	-	-	-	-	-
	MRIq Leisure-time activities	-	-	-	-	-	-
	MRIq Sports activities	-	-	-	-	-	-
	MRIq Caregiving	-	-	-	-	-	-
	MRIq Work activities	-	-	-	-	-	r = - 0.39, p<0.01
	MRIq Total score	-	-	-	-	-	-

CONCLUSIONS

Conclusions (1)

1. Engagement in **walking activities** over the **past 12 months** is positively associated with **accuracy** in working memory tasks
    - Regular walking over the past year may improve brain function by **increasing blood flow and supporting neural health**, which enhances working memory accuracy
    - Walking also **reduces stress and promotes overall physical health**, factors that can contribute to better cognitive performance in memory tasks

Conclusions (2)

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2. **Lifetime** engagement in **physically active work** is negatively associated with **reaction times**, suggesting enhanced processing speed

   - Lifelong engagement in physically active work **may enhance cerebral blood flow, neuroplasticity, and white matter integrity**, **supporting faster neural processing**
   - Such **work often involves complex motor-cognitive tasks** and reduces sedentary behavior, which together may help maintain or improve reaction speed over time

REFERENCES

References (1)

1. Baddeley, A. D. (2003). Working memory: Looking back and looking forward. *Nature Reviews Neuroscience*, *4*(10), 829–839. https://doi.org/10.1038/nrn1201
2. Baddeley, A. D., Allen, R. J., & Hitch, G. J. (2011). Binding in visual working memory: The role of the episodic buffer. *Neuropsychologia*, *49*(6), 1393–1400. https://doi.org/10.1016/j.neuropsychologia.2010.12.042
3. Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports (Washington, D.C.: 1974)*, *100*(2), 126–131.
4. Chang, Y., Huang, C., Chen, K., & Hung, T. (2013). Physical activity and working memory in healthy older adults: An ERP study. *Psychophysiology*, *50*(11), 1174–1182. https://doi.org/10.1111/psyp.12089
5. D'Antuono, G., Maini, M., Marin, D., Boccia, M., & Piccardi, L. (2022). Effect of ageing on verbal and visuo-spatial working memory: Evidence from 880 individuals. *Applied Neuropsychology: Adult*, *29*(2), 193–202. https://doi.org/10.1080/23279095.2020.1732979
6. Deng, J., Wang, H., Fu, T., Xu, C., Zhu, Q., Guo, L., & Zhu, Y. (2024). Physical activity improves the visual–spatial working memory of individuals with mild cognitive impairment or Alzheimer's disease: A systematic review and network meta-analysis. *Frontiers in Public Health*, *12*, 1365589. https://doi.org/10.3389/fpubh.2024.1365589
7. Diamond, A. (2013). Executive Functions. *Annual Review of Psychology*, *64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750
8. Herrmann, S. D., Willis, E. A., Ainsworth, B. E., Barreira, T. V., Hastert, M., Kracht, C. L., Schuna, J. M., Cai, Z., Quan, M., Tudor-Locke, C., Whitt-Glover, M. C., & Jacobs, D. R. (2024). 2024 Adult Compendium of Physical Activities: A third update of the energy costs of human activities. *Journal of Sport and Health Science*, *13*(1), 6–12. https://doi.org/10.1016/j.jshs.2023.10.010
9. Kirova, A.-M., Bays, R. B., & Lagalwar, S. (2015). Working Memory and Executive Function Decline across Normal Aging, Mild Cognitive Impairment, and Alzheimer's Disease. *BioMed Research International*, *2015*, 1–9. https://doi.org/10.1155/2015/748212
10. Levy, R. (2024). The prefrontal cortex: From monkey to man. *Brain*, *147*(3), 794–815. https://doi.org/10.1093/brain/awad389

References (2)

12. Nelson, C. A., De Haan, M., & Thomas, K. M. (2015). *Neuroscience of Cognitive Development: The Role of Experience and the Developing Brain* (1st ed.). Wiley. https://doi.org/10.1002/9780470939413
13. Nickel, M., & Gu, C. (2018). Regulation of Central Nervous System Myelination in Higher Brain Functions. *Neural Plasticity*, *2018*, 1–12. https://doi.org/10.1155/2018/6436453
14. Pauls, F., Petermann, F., & Lepach, A. C. (2013). Gender differences in episodic memory and visual working memory including the effects of age. *Memory*, *21*(7), 857–874. https://doi.org/10.1080/09658211.2013.765892
15. Peich, M.-C., Husain, M., & Bays, P. M. (2013). Age-related decline of precision and binding in visual working memory. *Psychology and Aging*, *28*(3), 729–743. https://doi.org/10.1037/a0033236
16. Pucci, V. (2024). *Modifiable lifestyle factors for cognitive health: The role of Cognitive Reserve and Motor Reserve* [Doctoral dissertation, Università degli Studi di Padova]. https://www.research.unipd.it/handle/11577/3520745
17. Pucci, V., Guerra, C., Barsi, A., Nucci, M., & Mondini, S. (2024). How long have you exercised in your life? The effect of motor reserve and current physical activity on cognitive performance. *Journal of the International Neuropsychological Society*, *30*(1), 11–17. https://doi.org/10.1017/S135561772300022X
18. Yokota, Y., & Naruse, Y. (2015). Phase coherence of auditory steady-state response reflects the amount of cognitive workload in a modified N-back task. *Neuroscience Research*, *100*, 39–45. https://doi.org/10.1016/j.neures.2015.06.010
19. Zhidong, C., Wang, X., Yin, J., Song, D., & Chen, Z. (2021). Effects of physical exercise on working memory in older adults: A systematic and meta-analytic review. *European Review of Aging and Physical Activity*, *18*(1), 18. https://doi.org/10.1186/s11556-021-00272-y

Thank you!