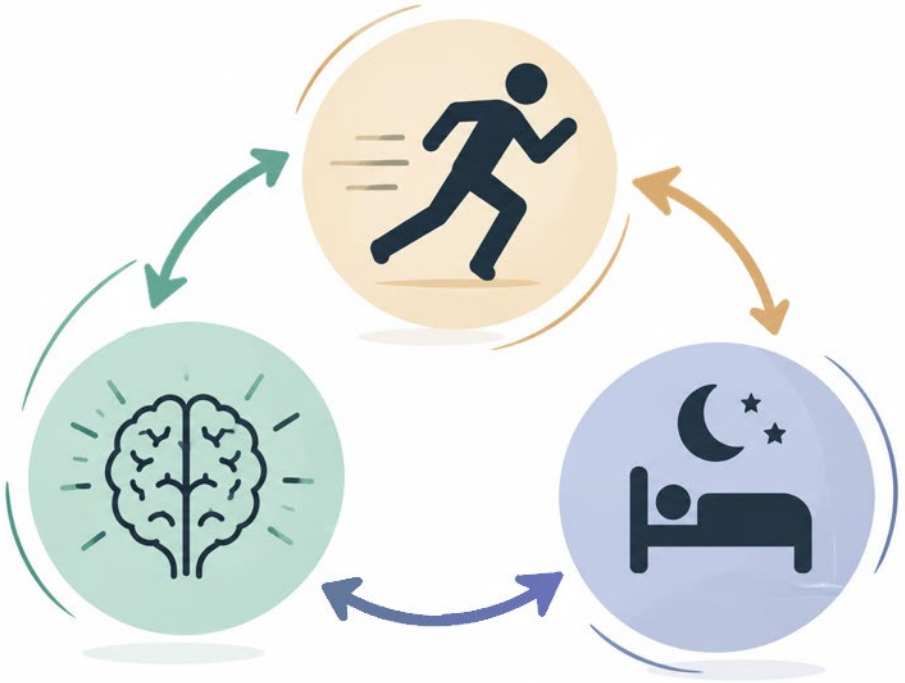


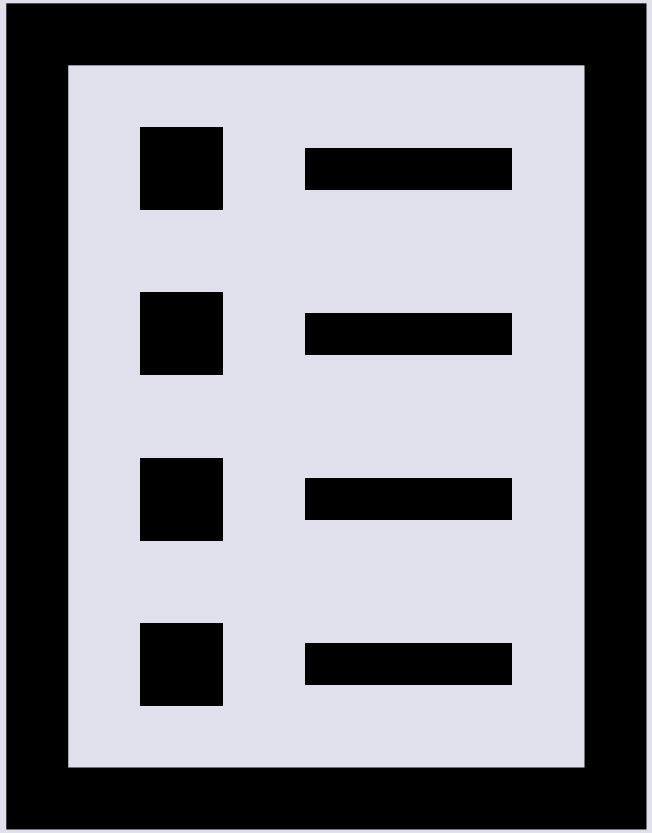
Interrelation between exercise, sleep and the aging brain

Selin Scherrer & Dr. Sven Egger
selin.scherrer@unifr.ch; sven.egger@unifr.ch

Project name: «*Promoting the modulatory capacity of intracortical inhibition in young and old: interrelation of physical exercise and sleep*» funded by the Swiss National Science Foundation.

Project partners: Prof. Dr. Wolfgang Taube, Dr. Benedikt Lauber, Dr. Sven Egger, Selin Scherrer, Dr. Lijing Xin, Dr. Xinyu Liu, Prof. Dr. Björn Rasch, Dr. Anna Wick

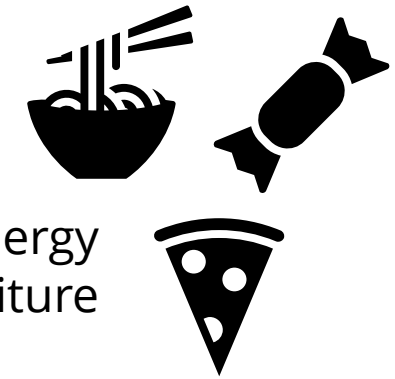
SWISS NATIONAL SCIENCE FOUNDATION



Content

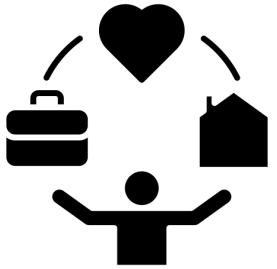
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Reasons to be Physically Active



Energy expenditure

Muscle growth /
Muscle maintenance

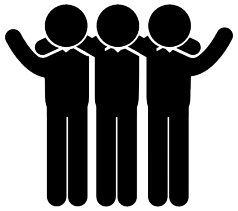


Better
Work-Life-Balance





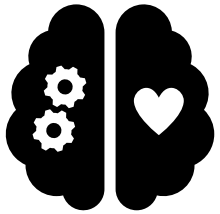
Physical
health



Maintaining
social
connections

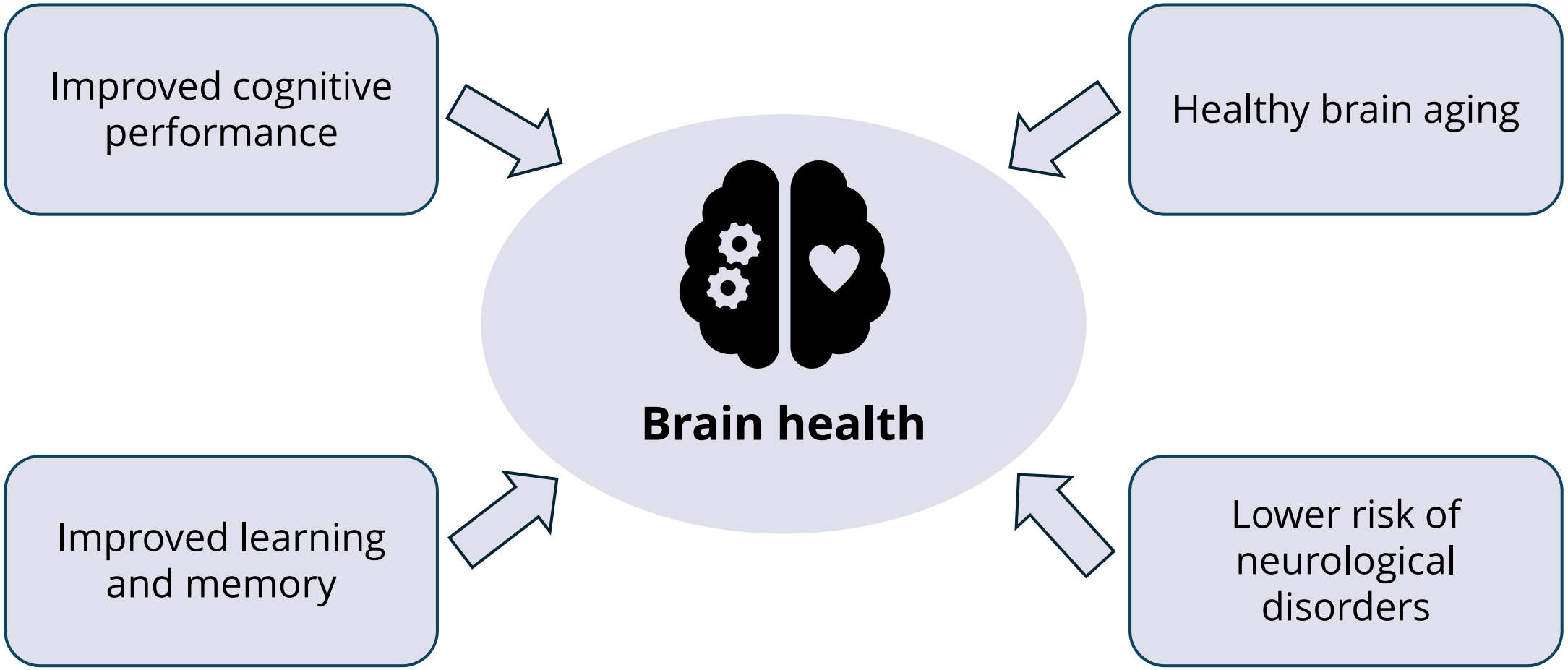


Improved self image



Brain health

Physical Exercise and the Brain

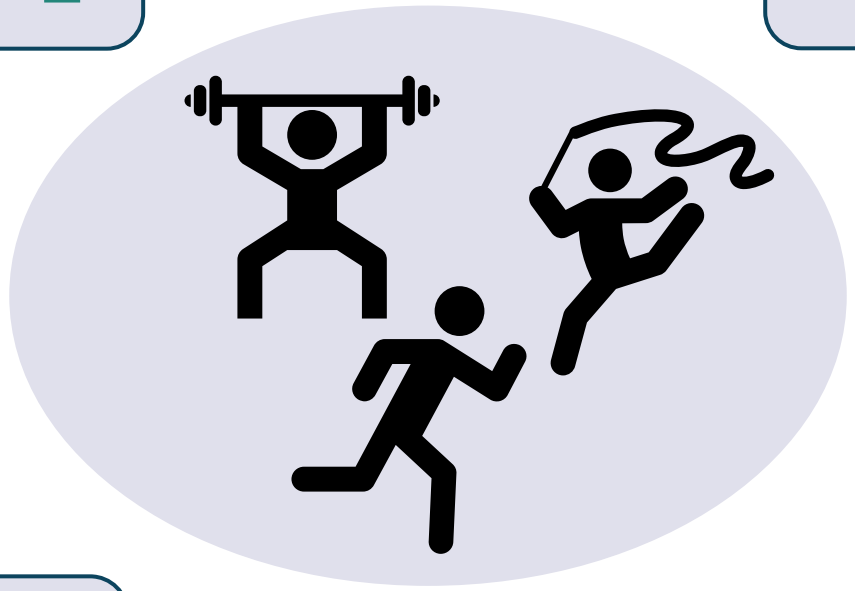


How does Physical Exercise Affect the Brain

Brain plasticity ↑

Brain vascularisation ↑

Neural protection ↑



Chronic inflammation ↓

Neurotransmitters
Growth factors ↑

Motor control
Motor learning ↑

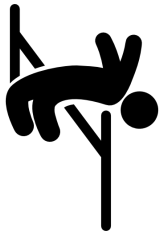
Vecchio et al. (2018)

Specificity - Effects of Balance Training



Improved explosive strength

Gruber & Gollhofer (2004)
Gruber et al. (2007)



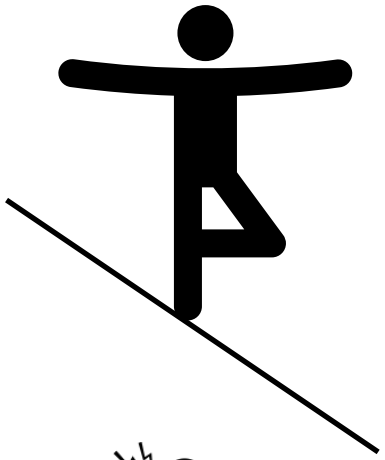
Improved jump performance

Taube et al. (2007)



Injury prevention

Verhagen et al. (2004)





Neck pain relieve

Beinert & Taube (2013)



Fall prevention

Sherrington et al. (2008)

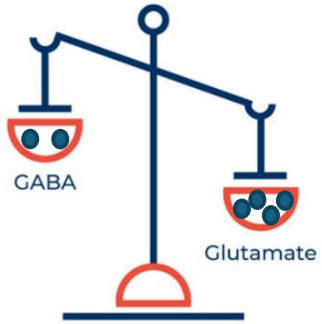


Faster rehabilitation

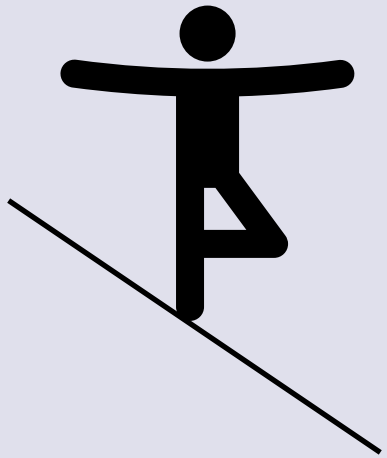
Freeman et al. (1965)

Effects of Balance Training on the Brain

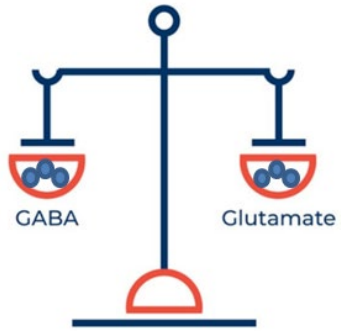
Before training



More neural excitation than inhibition



After training

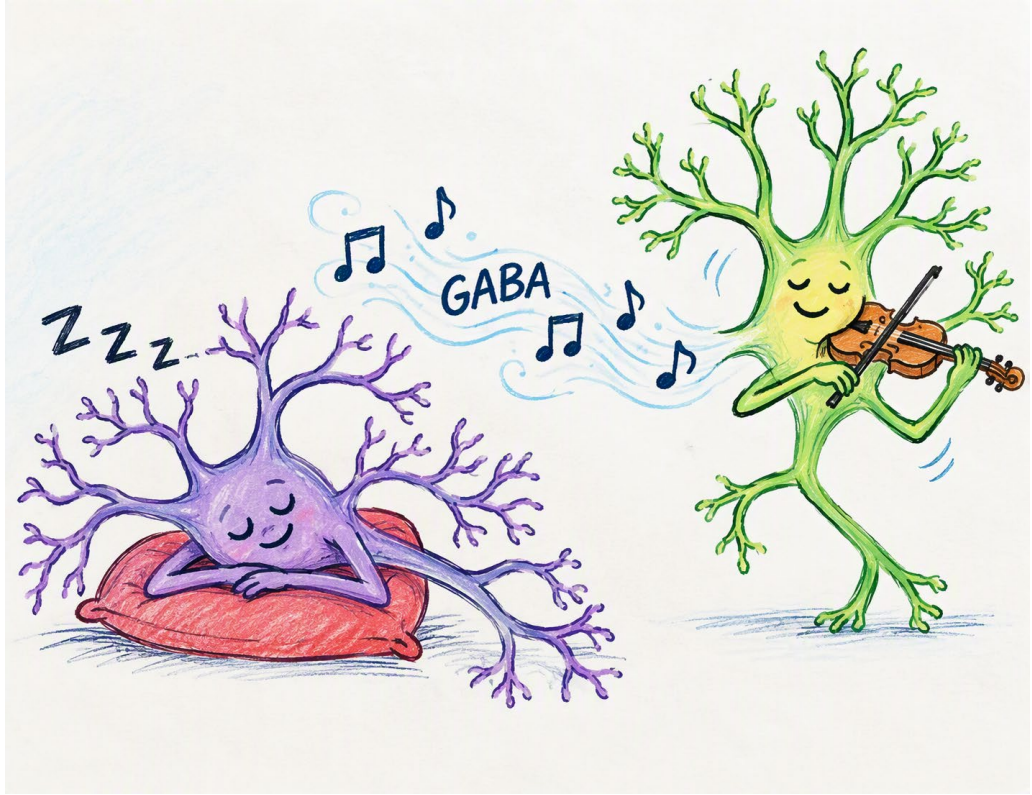


Balance between excitation/inhibition

Balance training can improve the **function of inhibitory neurons (GABA)**

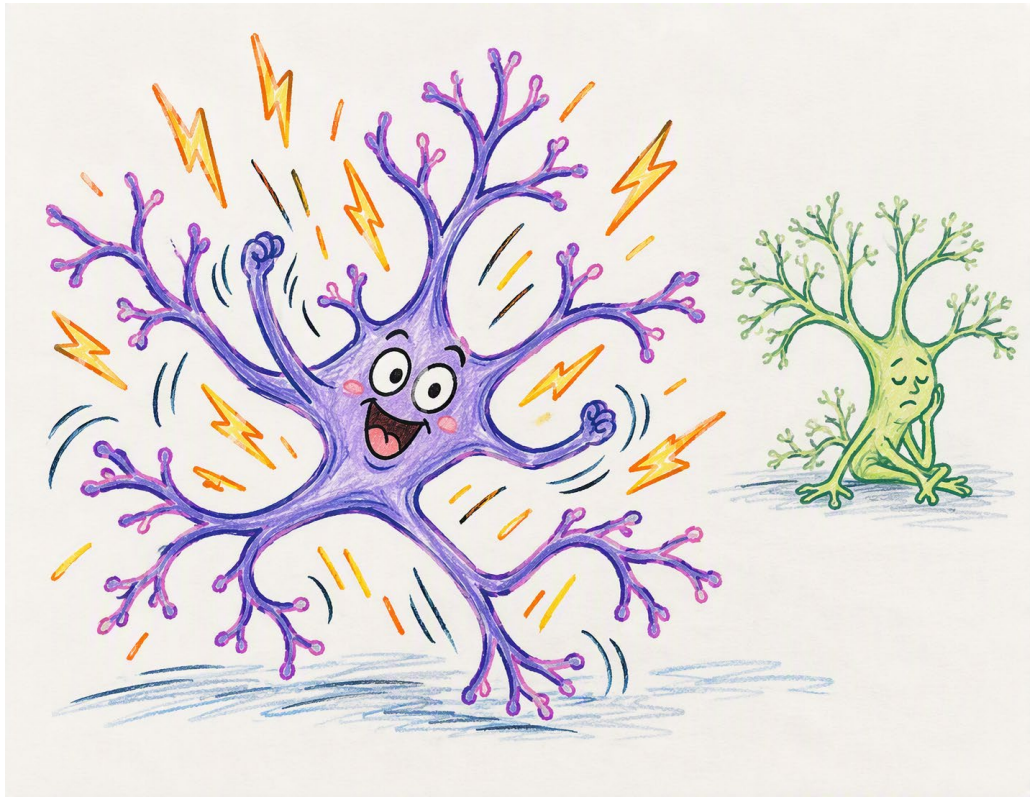
Mouthon & Taube (2019)
Kuhn et al. (2024)

Neuronal Communication – Inhibitory Neurons

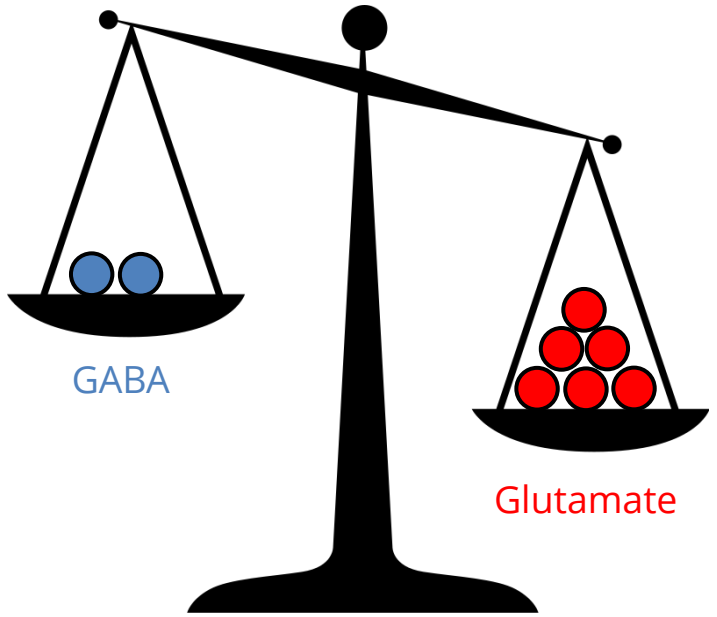


GABA *is the primary inhibitory neurotransmitter. It is released from* ***inhibitory neurons*** *and helps* ***regulate*** *and* ***control*** *the activity of other neurons. GABA is known for its* ***calming effect*** *and is often referred to as the* ***brain's «brake»*** *because it reduces neuronal excitability.*

Neuronal Communication - Imbalance

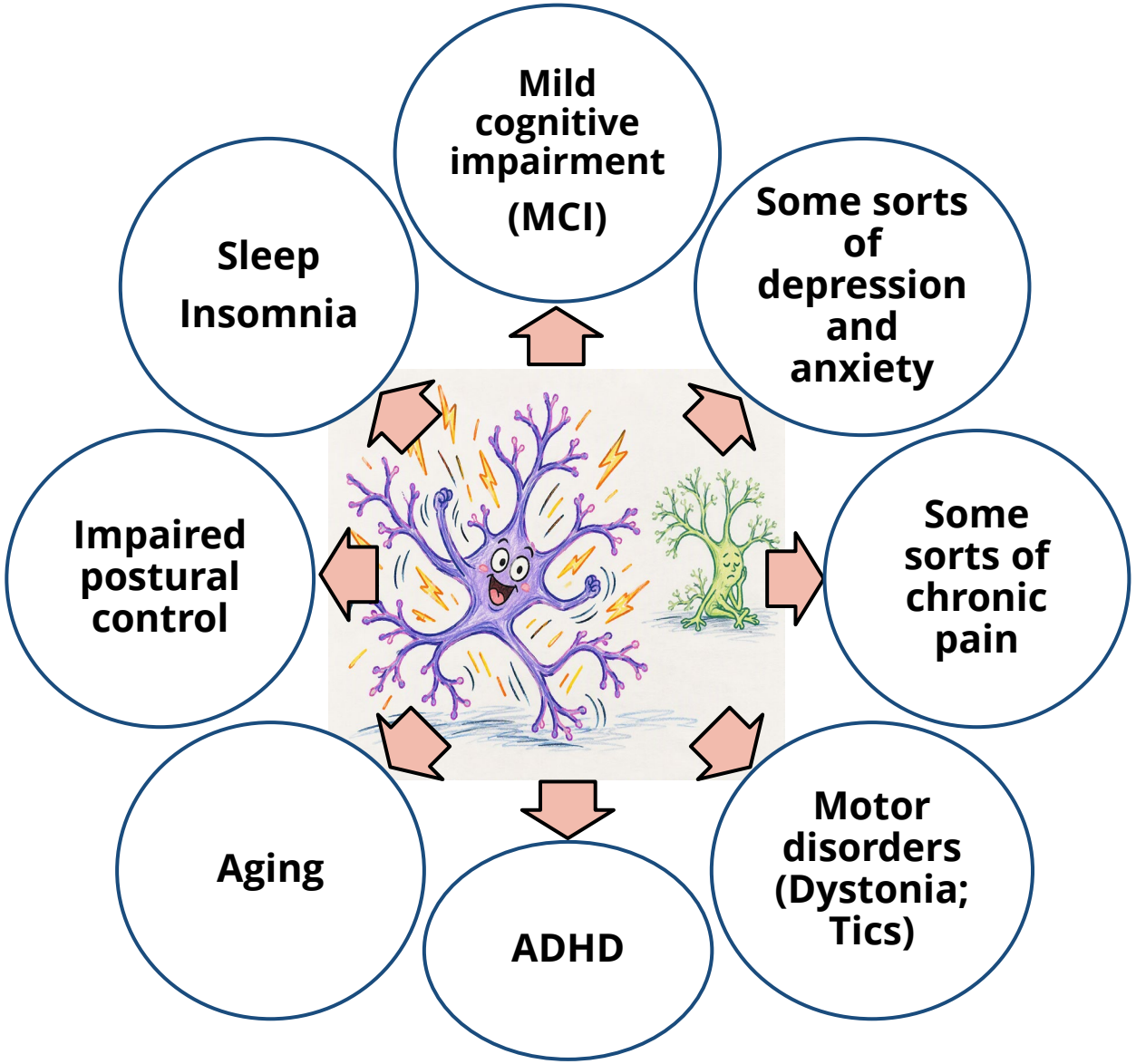


Imbalance between
exciation ...

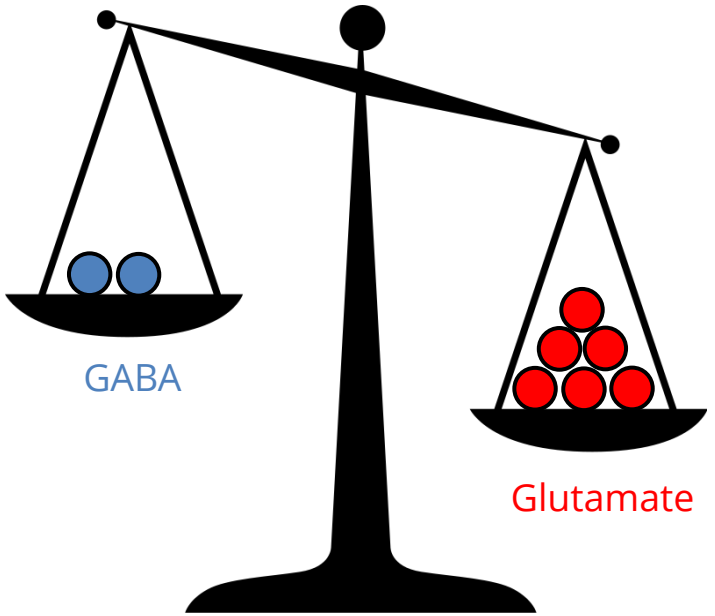


... and inhibition.

Consequences of Imbalance



Imbalance between excitation ...



... and inhibition.

Sport as Medicine / Prevention









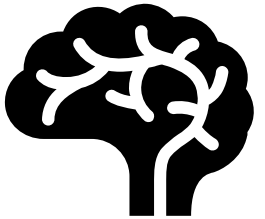


Which sport is good for your body, brain, and health condition?

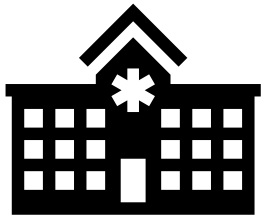
Which «pathological condition» is treated by which sport?



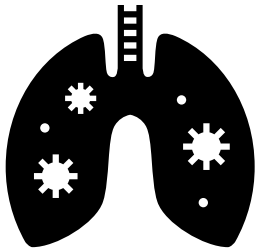


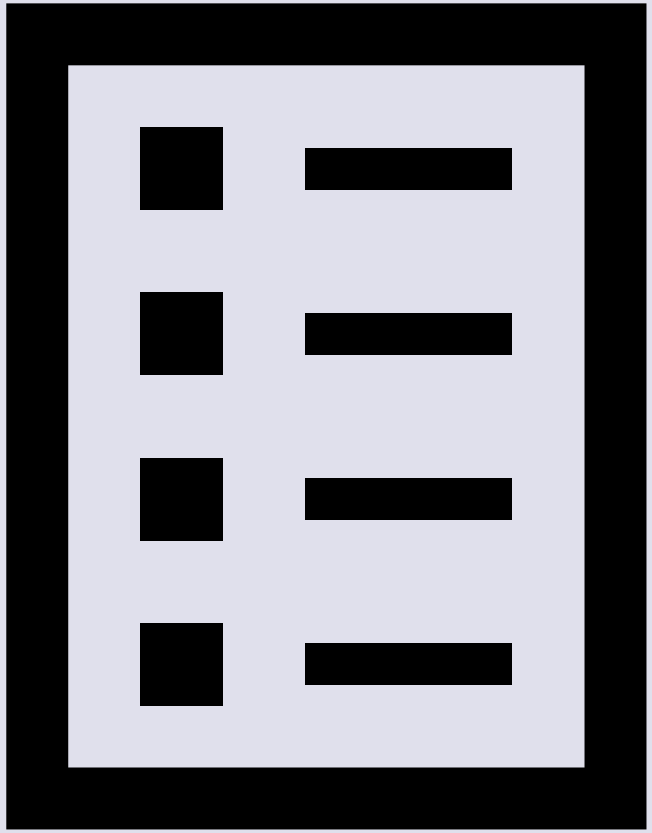








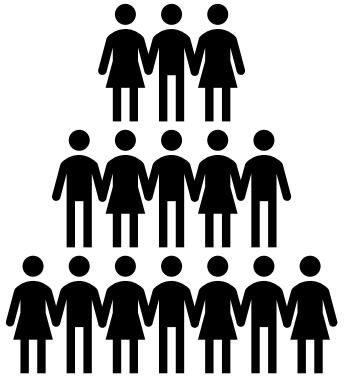




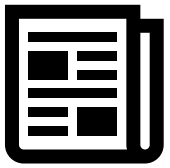
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The project by the numbers



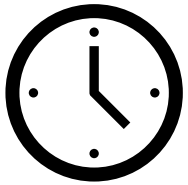
95
Participants



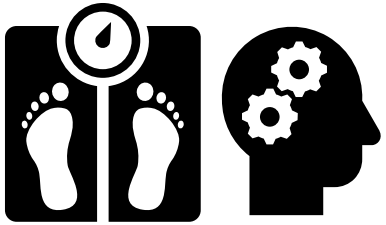
10
Academic publications



285
Night sleep assessments



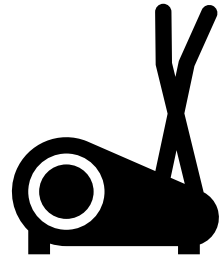
~2200 hours of data collection, corresponding to more than **260** working days



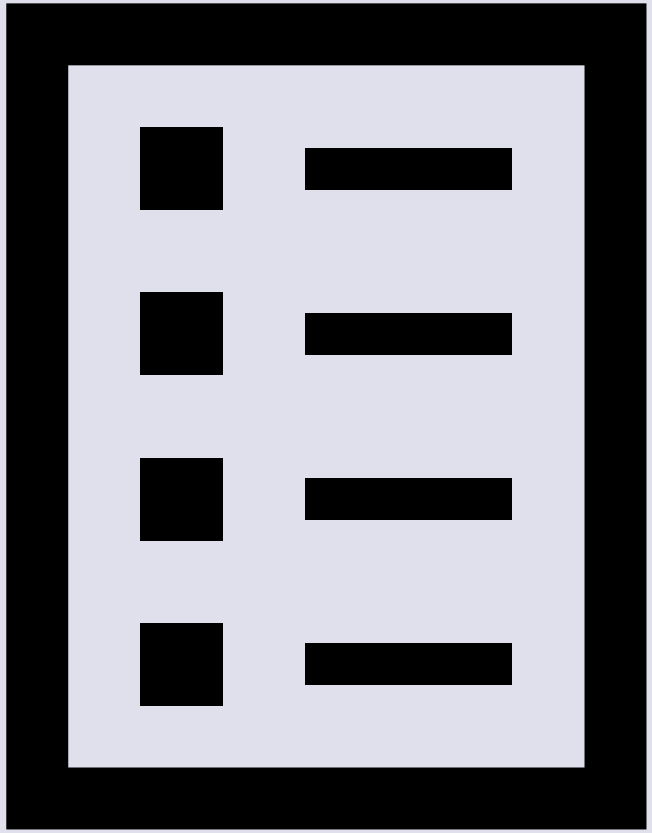
190
Study visits in the laboratory in Fribourg



190
MRI sessions



300
provided trainings

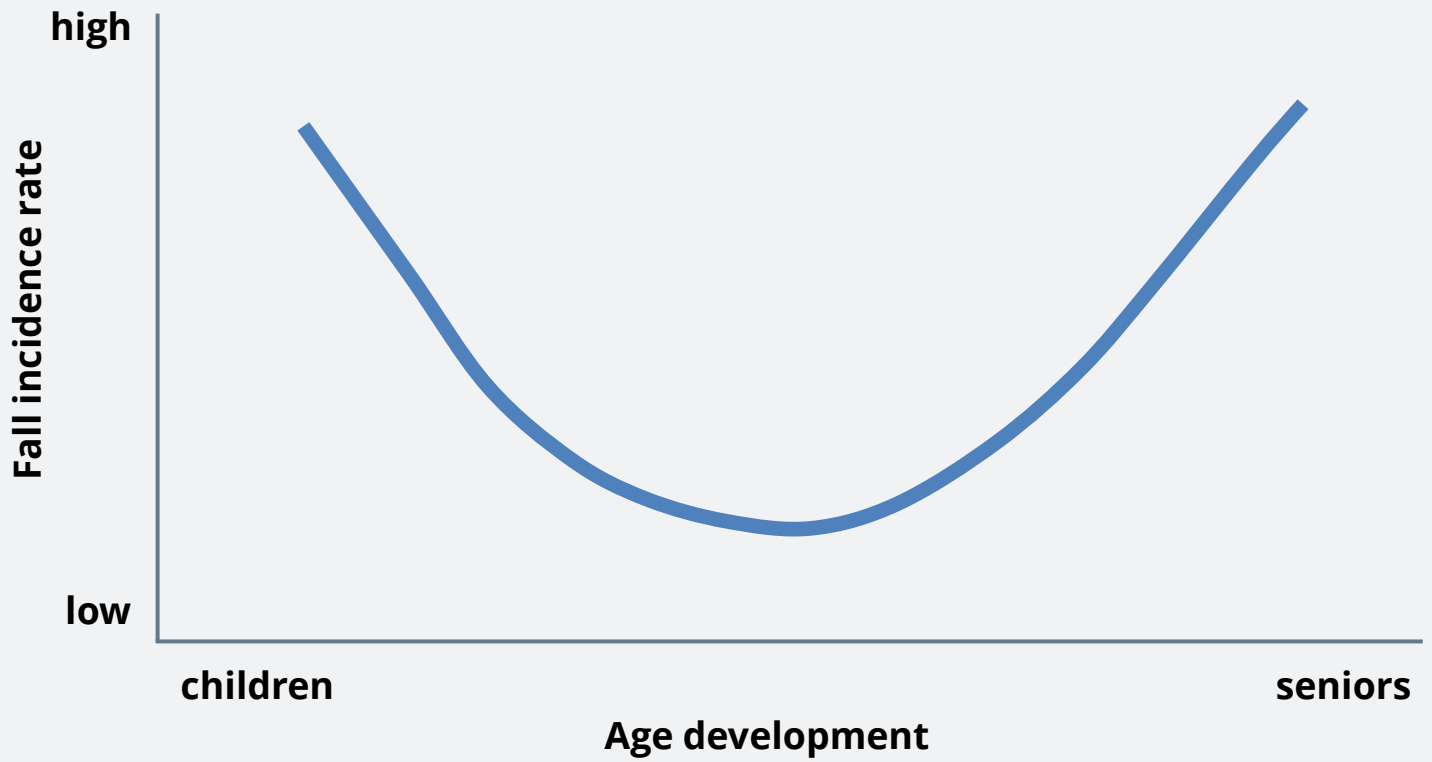


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Retrospective – Theoretical Background

Fall incidence rate throughout the lifespan



According to Granacher et al. (2011)

Childhood

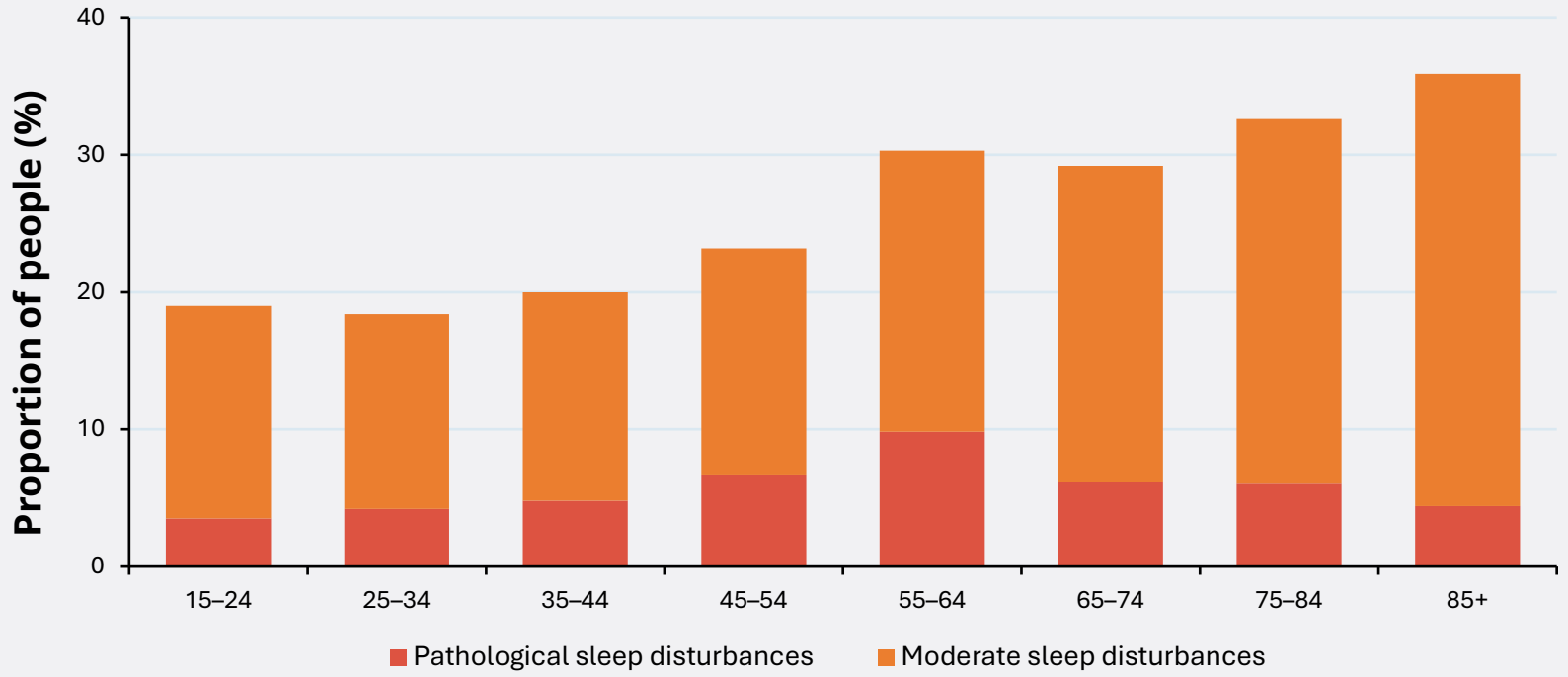
Higher fall rate, as we need to learn to walk and develop bipedal balance

Higher age

One third of all adults aged 65 or older fall at least once a year. This can lead to injuries and restraints in everyday life.

Retrospective – Theoretical Background

Sleep disturbances by age groups, 2012



BFS – SGB12, Neuchâtel (2015)

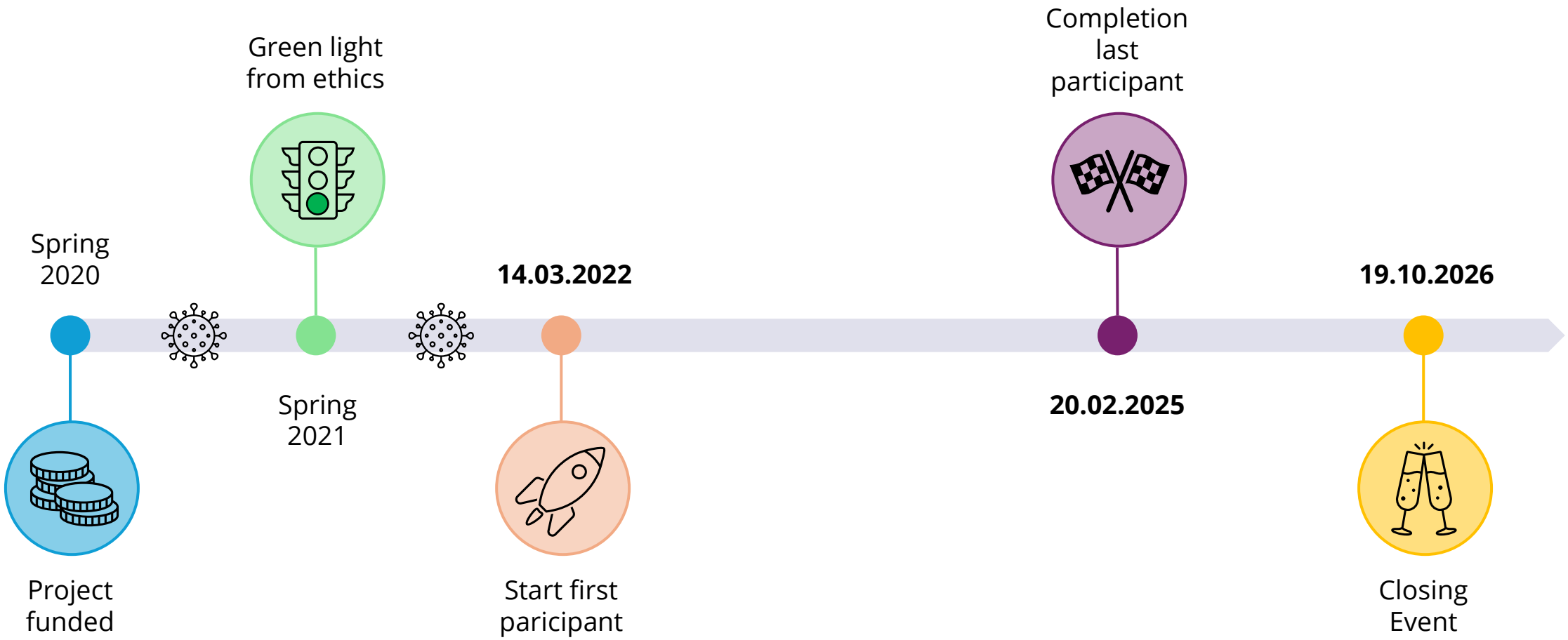
From 55 years

about **one third** of people report at least moderate sleep disturbances.

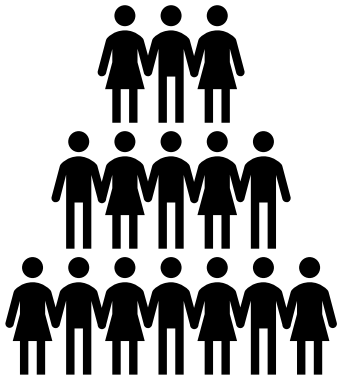
Why relevant?

Sleep disturbances may be accompanied by fatigue, concentration difficulties, and an increased risk of dementia.

Retrospective – Project Timeline



Retrospective – Group Allocation



95
participants



60 participants

70.4 years (64 – 81)

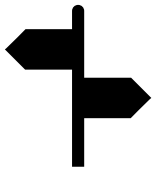
31 female, 29 male



Balance training



Resistance training



No specific training



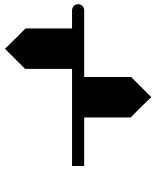
35 participants

26.5 years (18 – 35)

23 female, 12 male



Balance training



No specific training

Retrospective – Study Design

Information session

Baseline assessment



Physical & brain function



Brain chemistry & brain structure



Sleep quality

12-week intervention

2-3x per week



Balance training



Resistance training



No specific training

Outcome assessment



Physical & brain function



Brain chemistry & brain structure



Sleep quality

-2 0 12 14

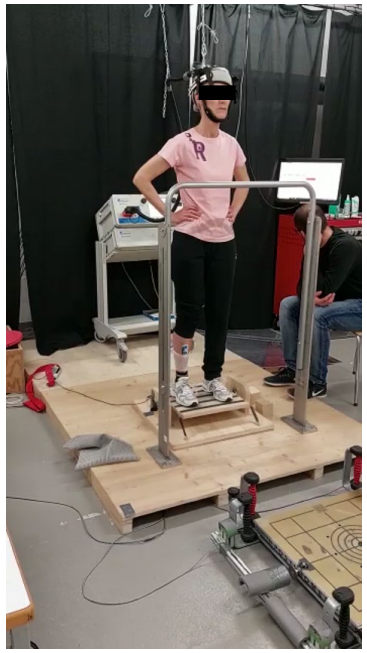
Time in weeks

Assessments

Physical & brain function

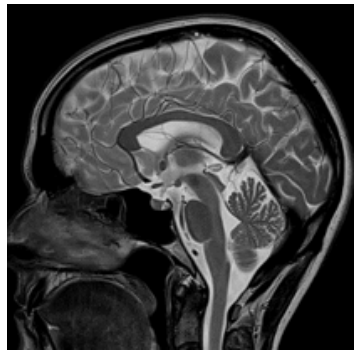
Brain chemistry & brain structure

Sleep quality

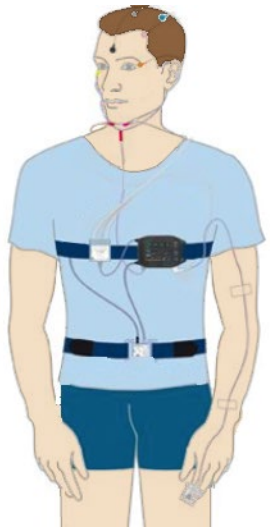


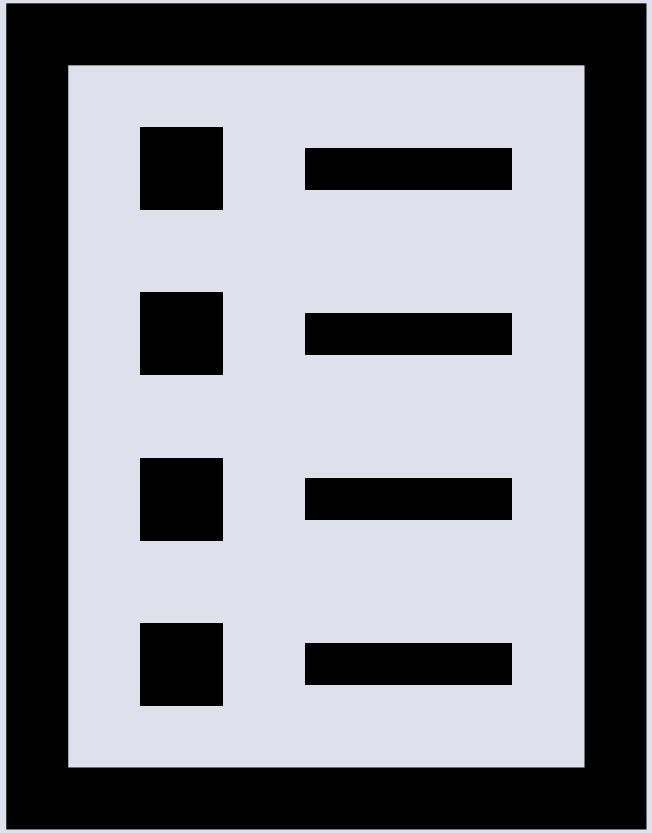












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Overview of Publications

1. Liu, X., Nossa, G., Xiao, Y., Scherrer, S., Egger, S., Lauber, B., Taube, W., Dydak, U., & Xin, L. (2026). Age-dependent macromolecule signals in the human motor cortex and thalamus: implications for metabolites quantification at 7 T. *Magma*. https://doi.org/10.1007/s10334-026-01419-7

2. Liu, X., Scherrer, S., Egger, S., Lim, S. I., Lauber, B., Jelescu, I., ... & Xin, L. (2024). Rebalance the inhibitory system in the elderly brain: Influence of balance learning on GABAergic inhibition and functional connectivity. Human brain mapping, 45(16), e70057. https://doi.org/10.1002/hbm.70057

3. Scherrer, S., Egger, S., Liu, X., Wick, A. Z., Rasch, B., Xin, L., Lauber, B., & Taube, W. (2026). Improved subjective sleep quality in older adults by enhancing the GABAergic system in the sensorimotor cortex. *The Journal of physiology, 604*(15), 6506-6546. https://doi.org/10.1113/jp290164

4. Scherrer, S., Egger, S., Liu, X., Wick, A. Z., Rasch, B., Xin, L., Lauber, B., & Taube, W. (2026). Reduced sensorimotor lactate concentration and improved sleep efficiency following resistance training in older adults. *Geroscience*. https://doi.org/10.1007/s11357-026-02519-x

5. Scherrer, S., Egger, S., Wick, A. Z., Xin, L., Lauber, B., Rasch, B., & Taube, W. (submtted). Bridging the Objective-Subjective Sleep Quality Gap: Evidence for Age-Specific Predictors of Sleep Perception

6. Liu, X., Egger, S., Scherrer, S., Pavan, T., Marques, J. P., Jelescu, I., Lauber, B., Taube, W., & Xin, L. (2026). Effects of strength and balance training on the structure of the aging brain. *NeuroImage, 339*, 122188. https://doi.org/10.1016/j.neuroimage.2026.122188

7. Liu, X., Scherrer, S., Egger, S., Lauber, B., Taube, W., & Xin, L. (2026). Functional and structural connectome-based predictive modelling of balance in elderly adults. *Scientific reports, 16*(1). https://doi.org/10.1038/s41598-026-43724-0

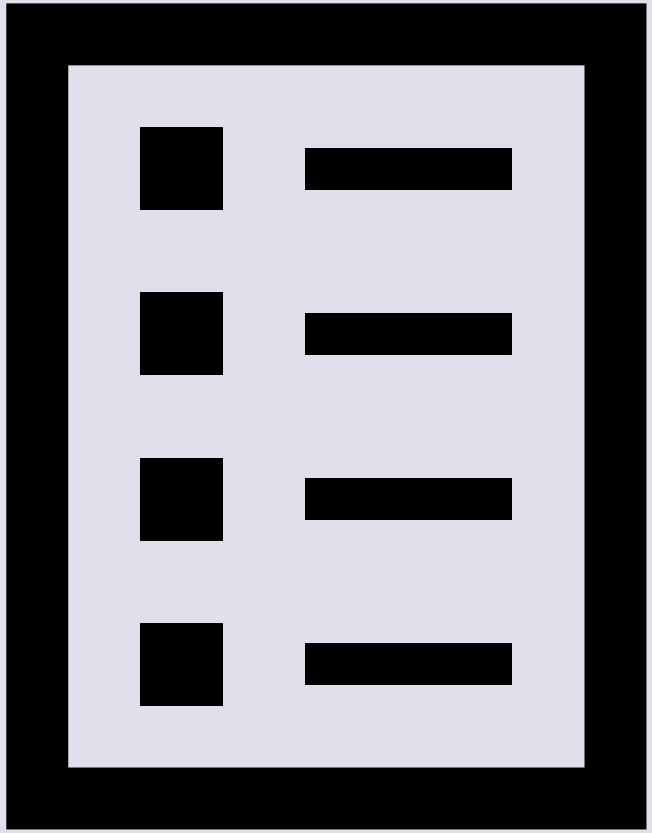
Further Project-Related Publications

8. Egger, S., Wälchli, M., Rüeger, E., & Taube, W. (2023). Short-term balance consolidation relies on the primary motor cortex: A rTMS study. *Scientific Reports*, *13*, 5169. https://doi.org/10.1038/s41598-023-32065-x

9. Taube, W., & Lauber, B. (2026). The ageing brain: Cortical overactivation – How does it evolve? *The Journal of Physiology*, *604*(2), 813–828. https://doi.org/10.1113/JP286891

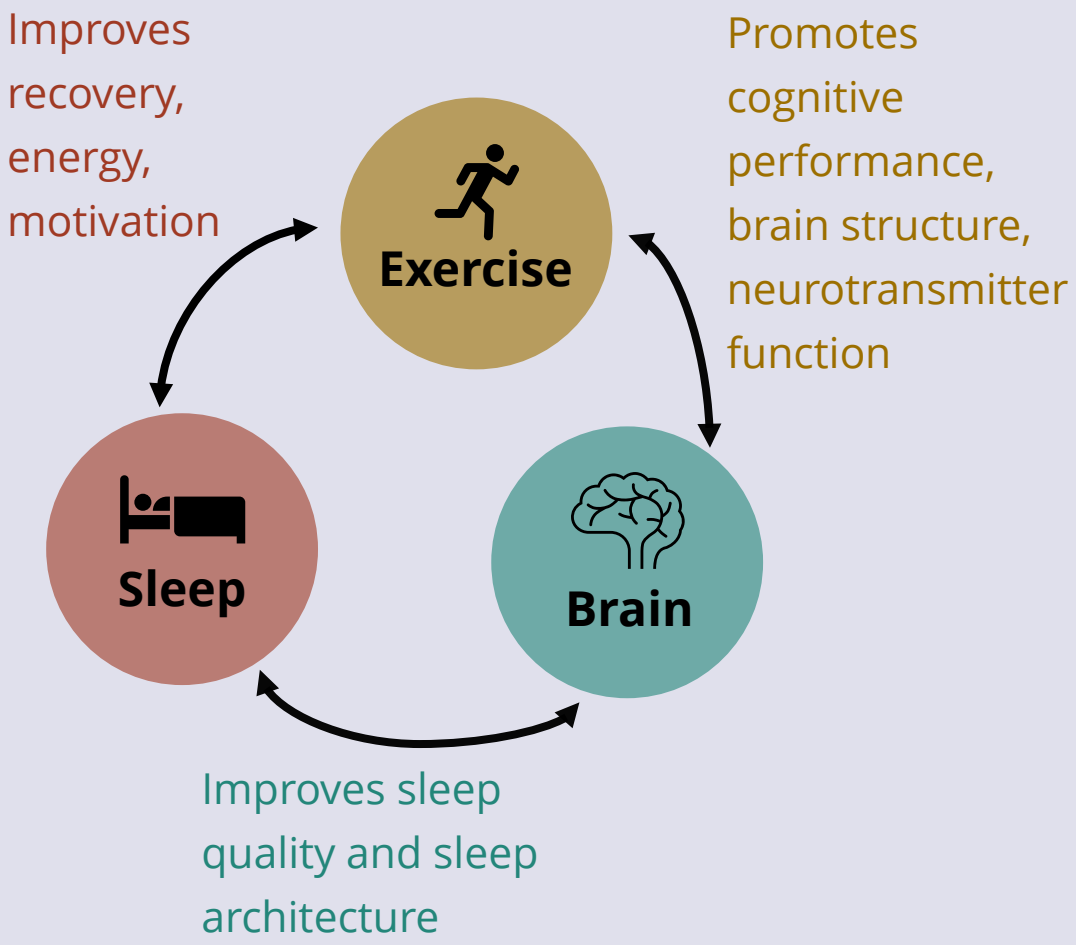
10. Taube, W., & Lauber, B. (2026). Changes in the cortical GABAergic inhibitory system with ageing and ageing-related neurodegenerative diseases. *The Journal of Physiology*, *604*(2), 689–706. https://doi.org/10.1113/JP285656





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Normal Changes with Aging

Motor function

- Decreased muscle strength
- Impaired balance
- Slower motor learning

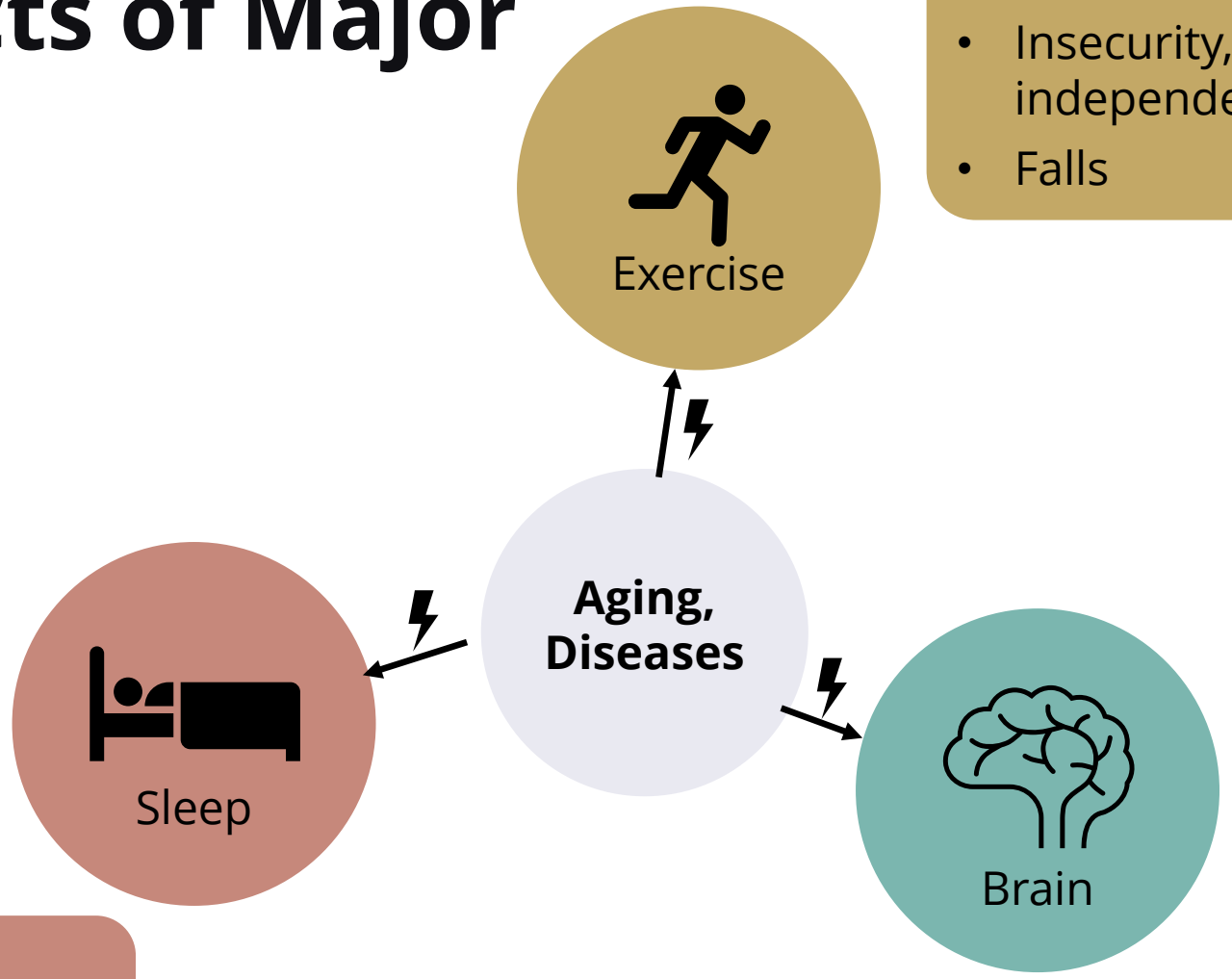
Sleep

- Lighter, shorter, more fragmented sleep
- More frequent sleep disorders

Brain

- Decreased brain inhibition (GABA), less efficient neural communication
- Energy production with oxygen is less efficient

Potential Effects of Major Changes



- Motor impairments
- Insecurity, loss of independence
- Falls

- Impaired quality of life
- Risk factor for diseases (dementia)

- Risk factors for diseases
- Impaired memory

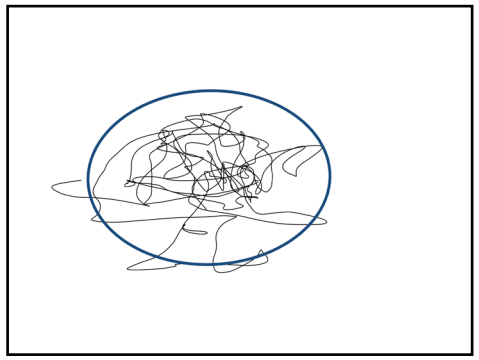
Baseline: Age-Group Differences in Motor Function

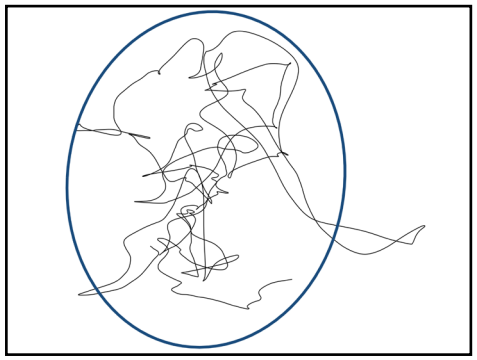




Balancing on wobble board



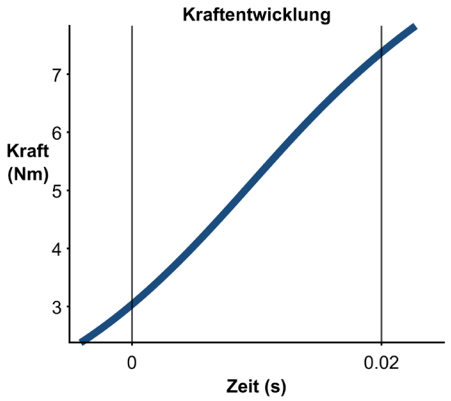


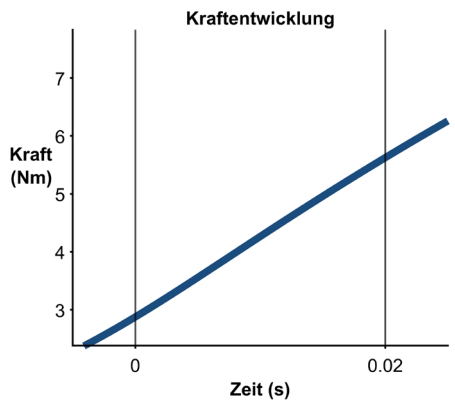


The older group swayed across a **34 %** larger area

Explosive foot dorsiflexion







The older group generated force **17 %** slower

Baseline: Age-Group Differences in Sleep





Subjective sleep quality

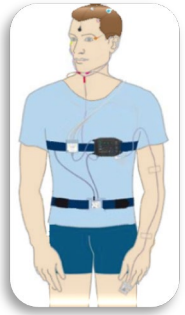


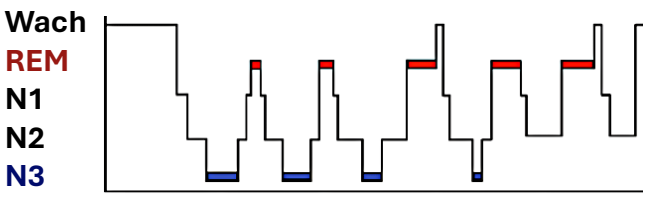


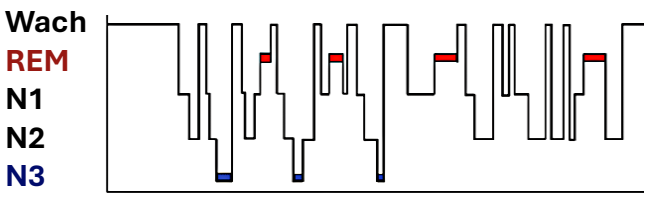


The older group rated their sleep quality **17 %** lower

Objective sleep quality







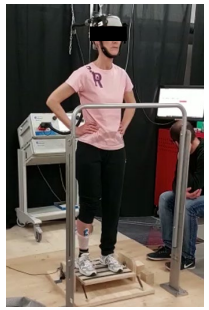
Older group:
12 % shorter sleep
89 % more awake
42 % less deep sleep

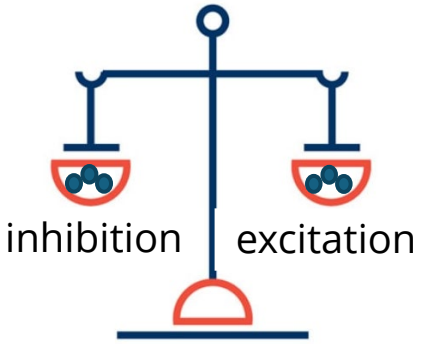
Baseline: Neural Age-Group Differences

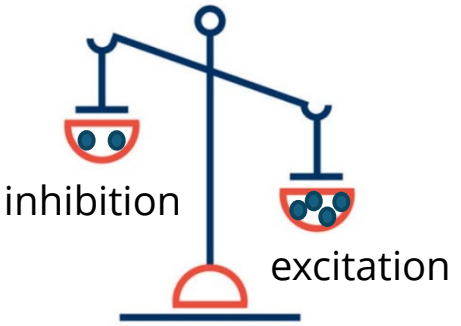




Functional brain inhibition



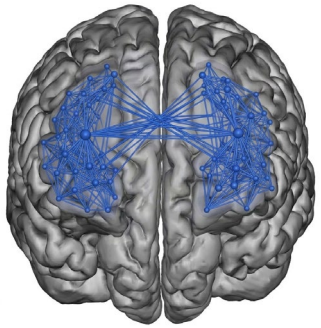


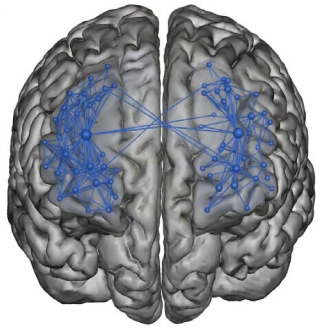


The older group exhibited **61 %** less inhibition during balancing

Communication between hemispheres







The older group showed **24 %** less communication between the hemispheres

Knowledge Gap

Most studies have examined general exercise or physical activity, without considering that different types of exercise have distinct effects on the brain and healthy ageing.

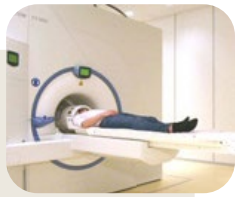
We compare two training modalities to investigate how targeted training positively influences the ageing brain and sleep.

Balance training	Resistance training
3 months of training to improve coordination and stability	3 months of training for muscle growth and explosive muscle strength

We investigated: brain function, brain metabolism, sleep quality, brain structure, ...

Improved Analysis for Better Science





Methods: Magnetic Resonance Spectroscopy (MRS)

Participants: All groups

Analysis: Analysis using different reference values

Measurement results can be substantially biased when reference values from different age groups or brain regions are used.

To accurately capture true changes, reference values must be **adjusted for age and brain region**. Otherwise, measurement errors can occur.



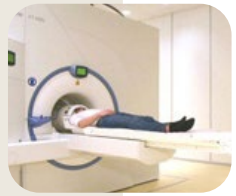
PUBLICATION 2 · LIU ET AL., 2024, HUMAN BRAIN MAPPING

Balance Training Improves Brain Function

Methods: MRS, functional Magnetic Resonance Imaging (fMRI)

Participants: Older balance training and control groups

Analysis: What changes in the brain through balance training?



More GABA

Increased GABA concentration, leading to improved brain activity regulation.

Stronger Connectivity

Improved functional connectivity between hemispheres.

«Younger» brain function after balance training

After three months of balance training, brain function became more similar to that of younger adults.

PUBLICATION 3 · SCHERRER ET AL., 2026, THE JOURNAL OF PHYSIOLOGY

Balance Training Improves Sleep Quality



Methods: Sleep questionnaires, TMS during afternoon nap

Participants: Older balance training and control groups

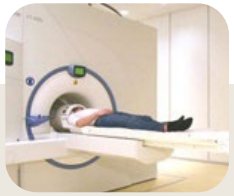
Analysis: How does balance training affect sleep?



Increased inhibition during sleep initiation went along with **improved subjective sleep quality**.

Balance training improved sleep quality – without medication and negative side effects. Subjective sleep quality is relevant for **quality of life**.

Resistance Training: Lower Lactate, Better Sleep





Methods: Night sleep assessment, MRS

Participants: Older resistance training and control groups

Analysis: Does resistance training affect sleep and brain?

- More efficient **energy metabolism in the brain**
- Improved **sleep efficiency**, less **wakefulness after sleep onset**, longer **total sleep time**

Resistance training improved objective sleep without participants perceiving the change. The improvements in sleep and energy metabolism may **reduce dementia risk**.



Sleep Perception Differs Between Age Groups





Methods: Sleep questionnaires, night sleep assessment

Participants: All groups

Analysis: Does sleep perception in older adults differ from younger adults?

Younger Adults

Perceived sleep quality was better after **longer total sleep time**.

Older Adults

Perceived sleep quality was better after **more restorative sleep**.

Sleep Quality Perception Differs Between Age Groups

Good subjective sleep quality in older adults appears to depend on obtaining sufficient REM and deep sleep.

PUBLICATION 6 · LIU ET AL., 2026, NEUROIMAGE

Both Training Modalities Protect Brain Structure



Methods: MRI

Participants: All older groups

Analysis: How do balance and resistance training affect brain structure?



Balance Training

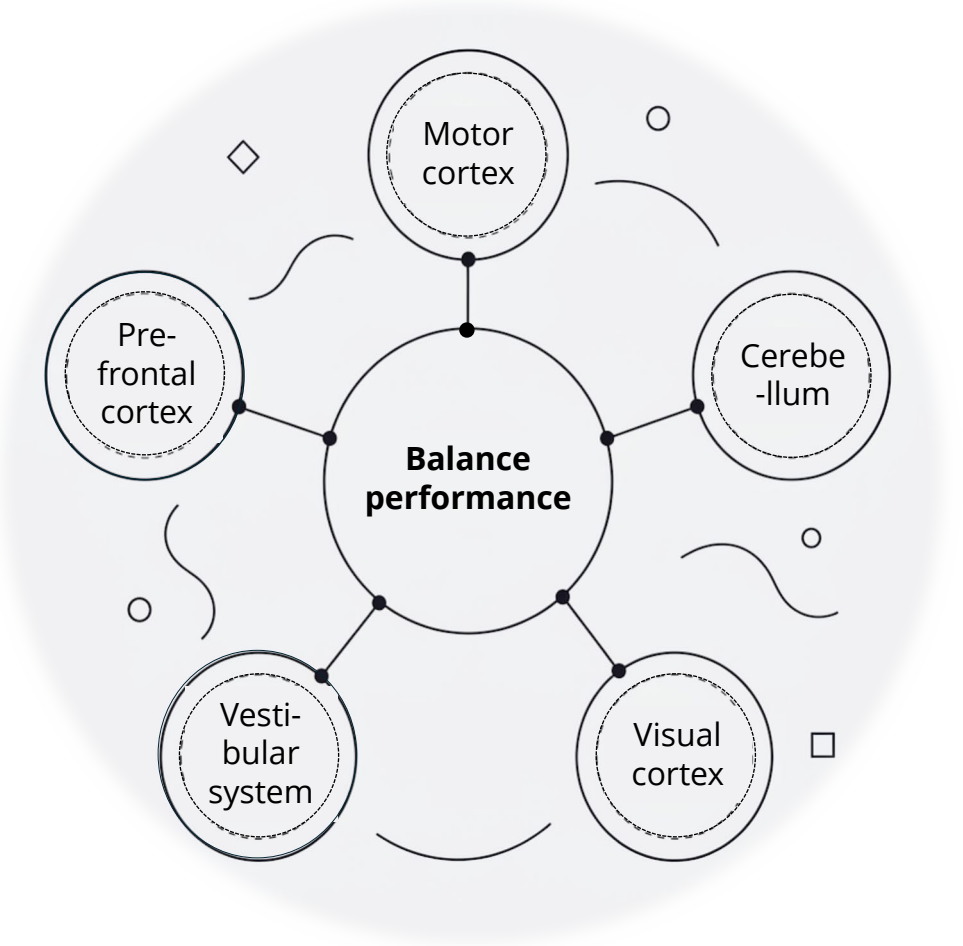
Preservation of neural connections through coordinative challenges

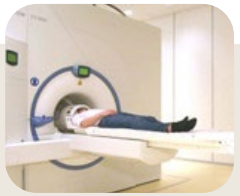
Resistance Training

Protection of brain structure through physical load

Both training modalities counteracted the age-related decline in **structural neural connectivity** and **supported brain health**.

Which Brain Connections Predict Balance Performance?





Methods: MRI, balance performance

Participants: All older groups

Analysis: Identification of structural and functional connections associated with balance perfromance in older adults.

Balance performance does not depend on a single brain region. Instead, it emerges from the coordinated activity of multiple regions.

Not one region – but **a network of brain regions predicts good balance performance**.

Exercise is Important for Healthy Aging

Exercise Modality Determines Specific Adaption

Balance training

- Improves **inhibition** and **functional connectivity** in the brain
- Improves **subjective sleep quality**

Resistance training

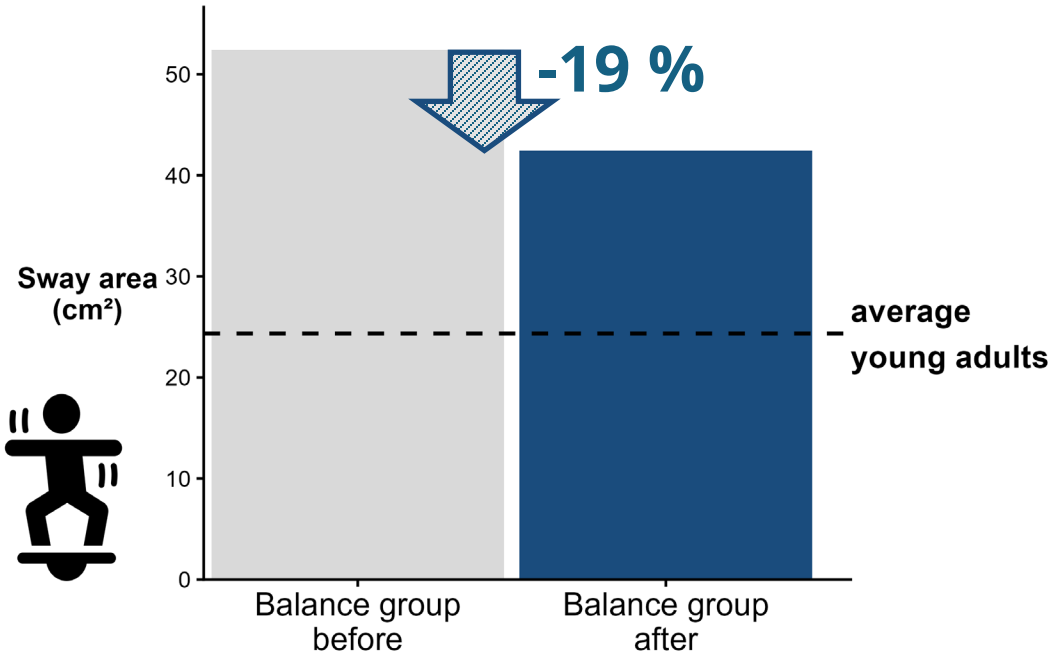
- Improves **brain metabolism**
- Increases **sleep duration** per night

Both modalities

- Protect **brain structure** from degeneration, improve **structural brain connectivity**
- Support **healthy aging**

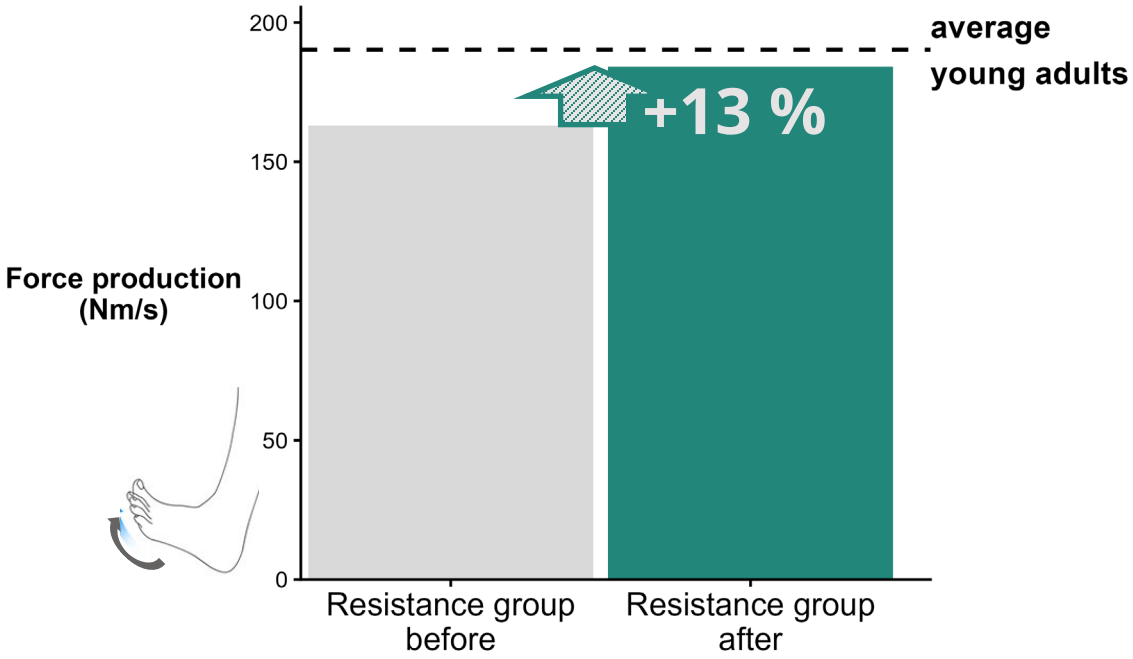
Reduced Motor Differences Between Age Groups After Training

Balance performance of older adults approaches the level of younger adults after training.



Balance training

Explosive strength performance of older adults approaches the level of younger adults after training.

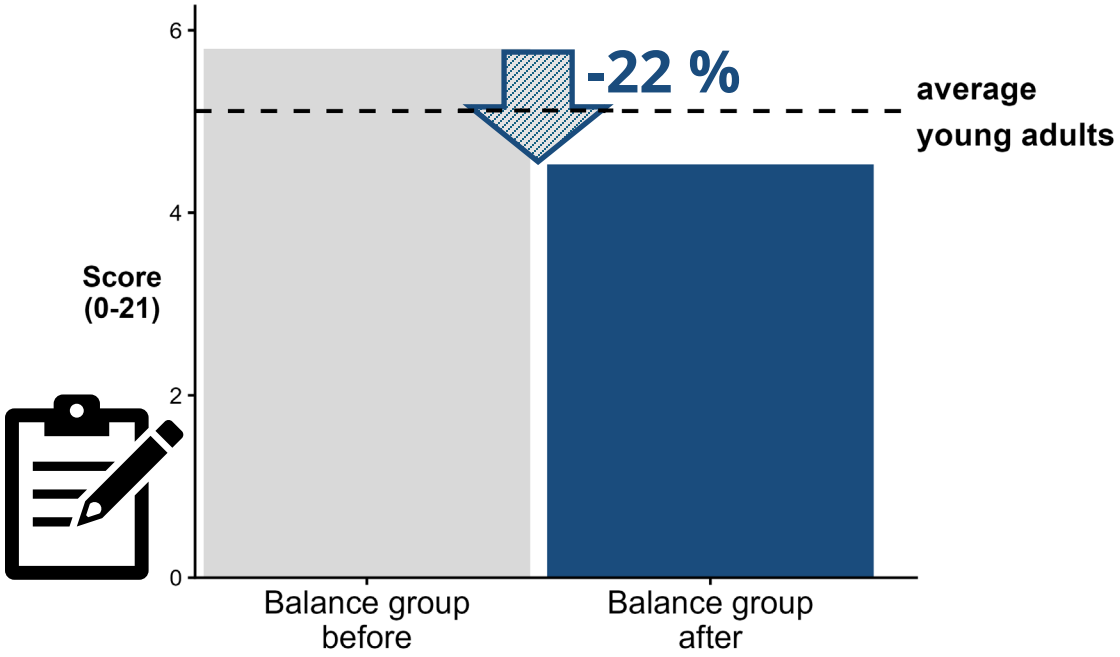


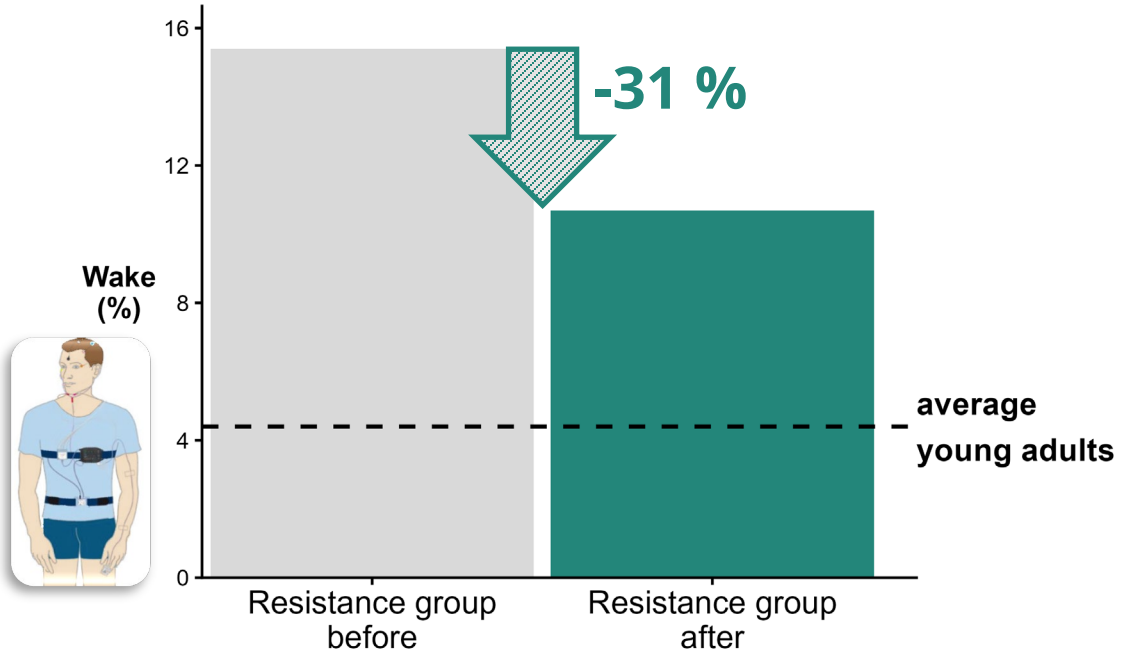
Resistance training

Reduced Sleep Differences Between Age Groups After Training

Subjective sleep quality in older adults **even exceeds** the baseline level of younger adults after training.

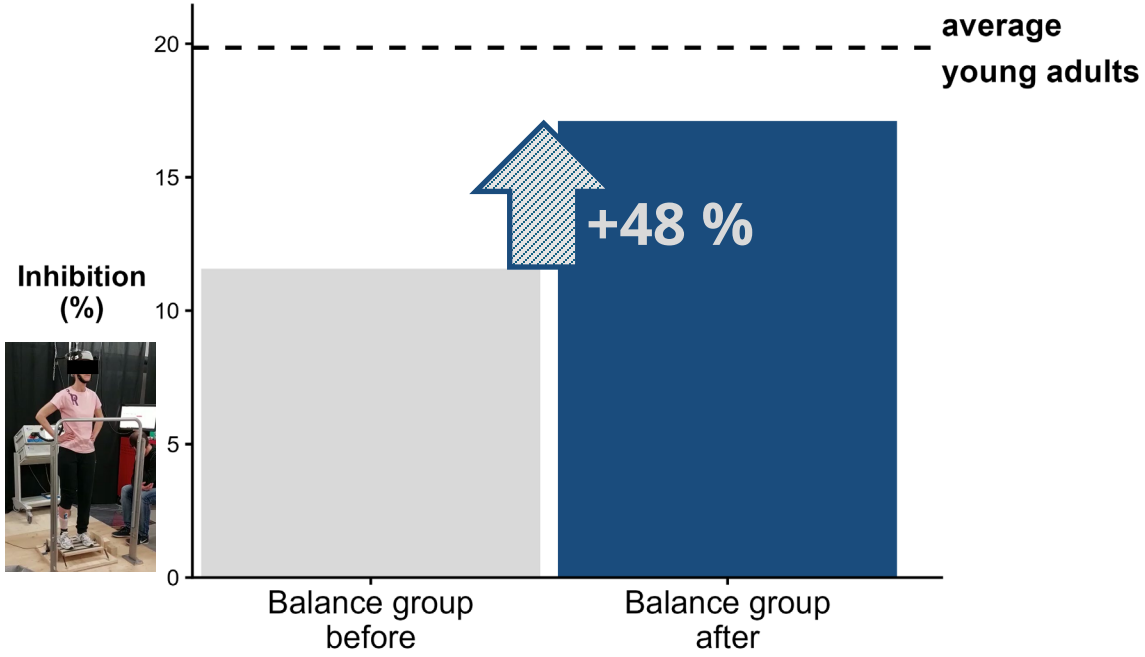
Objectively measured sleep fragmentation in older adults approaches the level of younger adults after training.



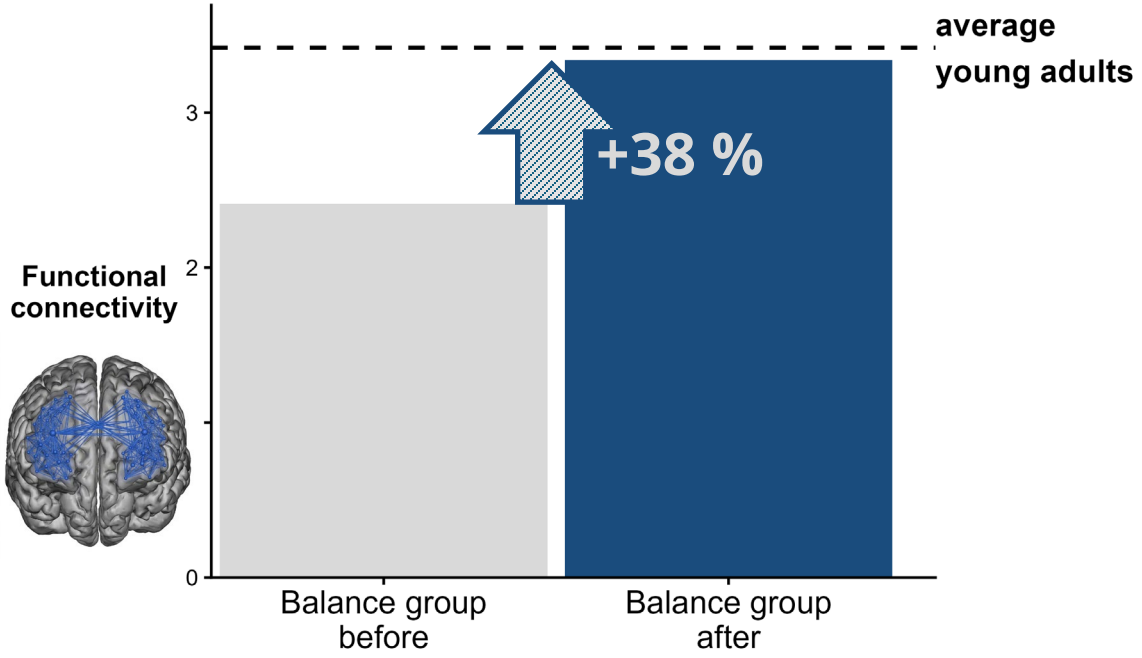


Reduced Brain Differences Between Age Groups After Training

Brain inhibition during a balance task in older adults approaches the level of younger adults after training.



Functional connectivity between hemispheres in older adults approaches the level of younger adults after training.



Take Home Message

Specific adaptations are achieved after just three months of balance or strength training. Ideally, both should be combined.



Non-invasive, no medication, and without side effects



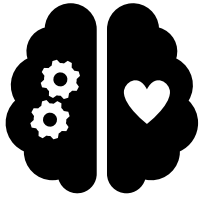
Improves sleep quality



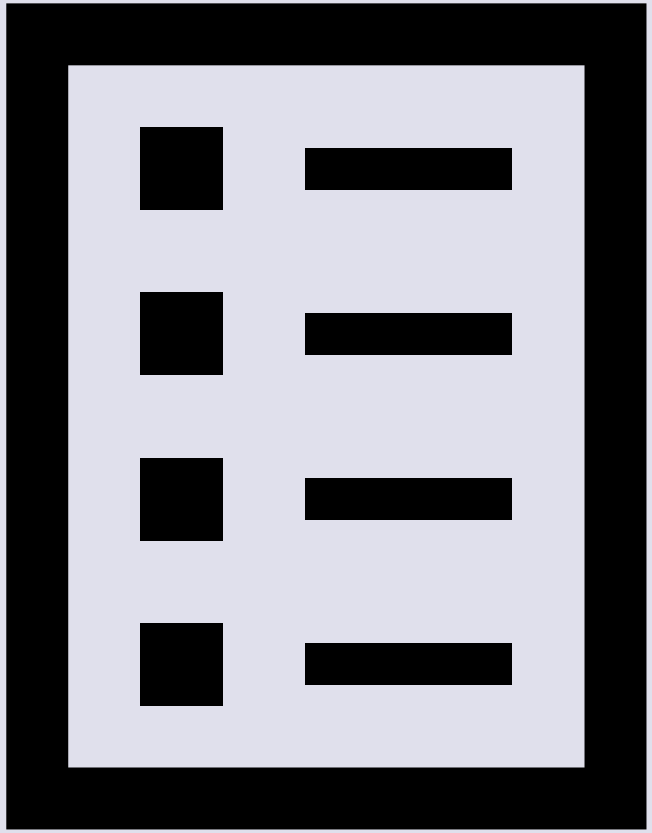
Improves stability and reduces the risk of falls



Accessible and feasible for most older adults



The brain remains capable of learning and adapting throughout life



Content

- General Introduction
- Key Facts and Figures about the Project
- Project Retrospective
- List of Publications
- Individual Publications and Key Findings
- **Acknowledgements**

Many thanks to all participants!







Including those in the control groups!

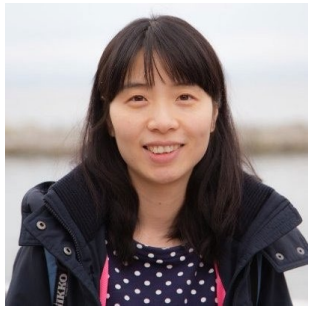
Many thanks to all project partners

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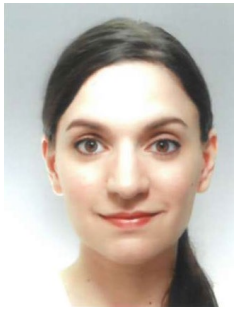

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References

- AI:
  - Individual images were created with the assistance of Gemini and Microsoft Copilot
- Icons:
  - Mirror icon (Slide 3): designed by Hajicon on Flaticon
  - Work-life balance (Slide 3): designed by logisstudio on Flaticon
  - Social contacts (Slide 3): designed by Magnific on Flaticon
  - Fall prevention (Slide 6): Shutterstock
  - Rehabilitation (Slide 6): designed by Magnific on Flaticon
  - Neck pain (Slide 6): iStock
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