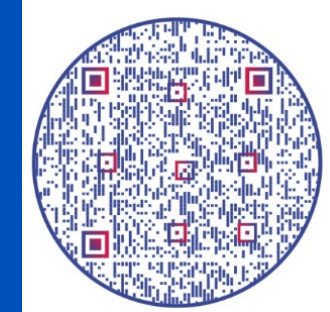




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BACKGROUND

Cerebrospinal fluid (CSF) circulation and its exchange with interstitial fluid (ISF) are critical components of the brain's waste clearance system and overall homeostasis. Impaired CSF flow has been linked to the accumulation of toxic proteins, such as amyloid ($A\beta_{42}$) and tau, which are hallmarks of neurodegenerative disease. While it is well-established that CSF dynamics are influenced by the respiratory and cardiac cycles, the impact of mind-body interventions—specifically Tai Chi—remains largely unexplored. *Tai Chi, characterized by slow, purposeful movements and controlled breathing, may offer a unique non-pharmacologic pathway to modulate neurofluid dynamics and support brain health in aging populations.*

OBJECTIVES

This study integrated multi-modal data to understand whether Tai-Chi practice was associated with CSF physiology, and risk of cognitive impairment. The objectives are:

1. To assess whether Tai Chi practice was associated with CSF oscillations and hence AD biomarkers
2. To assess whether Tai Chi practice was associated with cardio-respiratory improvements
3. To explore a potential mediating pathway linking Tai Chi, cardio-respiratory factors, CSF function, and AD risk.

METHODS

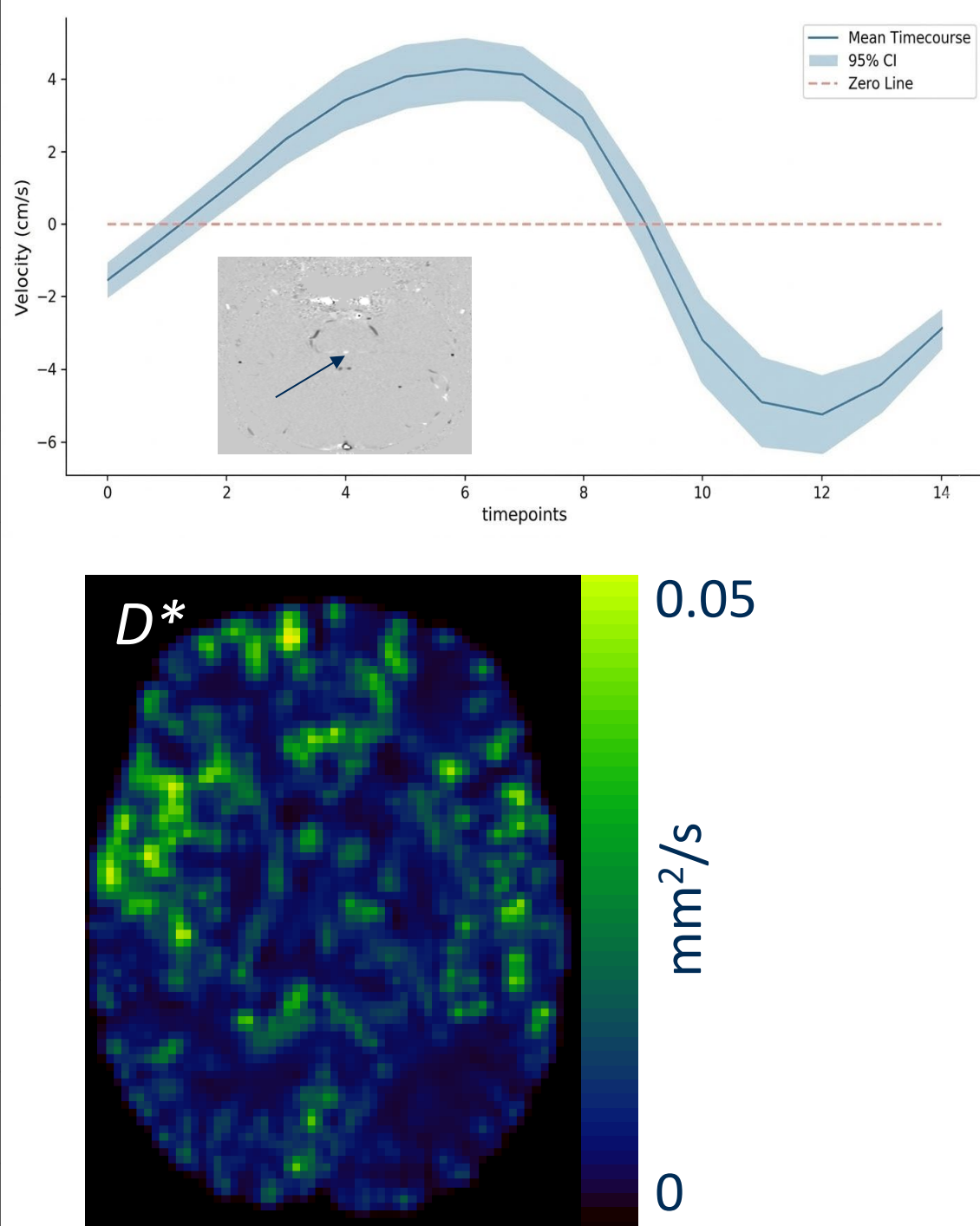
- **Study Population:** 30 cognitively normal, older adults (12M; age 67 ± 7 years) with varying levels of Tai Chi experience (TCC : 0-7)
- **Imaging:** Participants underwent a 3D T1; a phase-contrast scan for net CSF flow (craniocaudal or caudocranial) in the aqueduct; and IVIM MRI for CSF displacement in terms of diffusion D (laminar CSF flow), pseudo-diffusion D^* (incoherent shaking or stirring of CSF), and pseudo-diffusion fraction f (fraction of CSF experiencing incoherent motion). Cardiorespiratory measurements were conducted during the MRI scan using built-in Vital Eye sensors.

We tested the relationship between Tai Chi category (TCC) with D^* and Net Velocity, and between D^* and heart-rate, respiration, and plasma biomarkers. Finally, we tested whether TCC was associated with plasma biomarkers and if the associations were mediated by net velocity or D^*

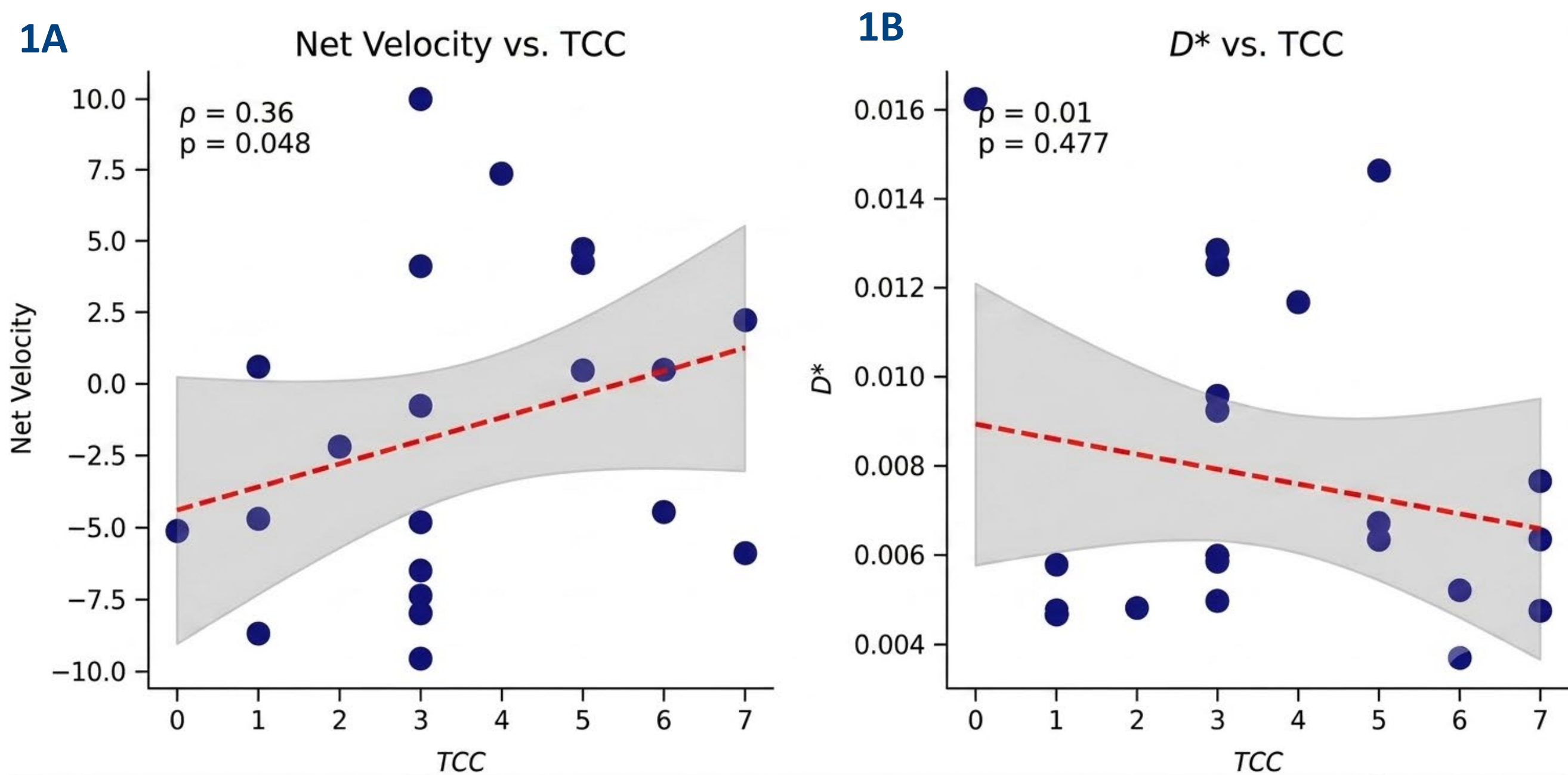
RESULTS

PARTICIPANT DEMOGRAPHICS

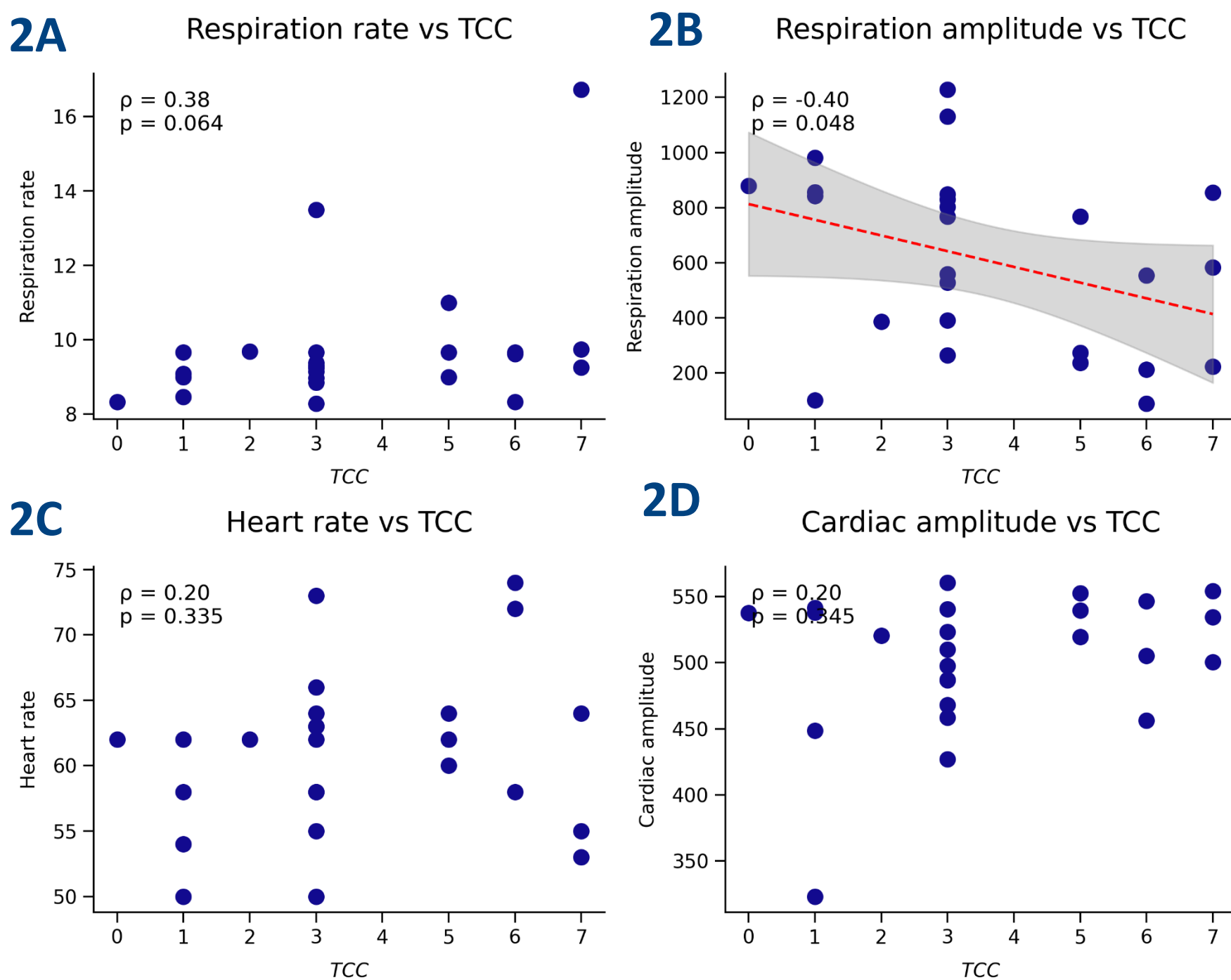
Characteristic	Value
Total Participants (N)	30
Gender (Male / Female / Other)	12 / 17 / 1
Age (years)	67.1 ± 7.6
Tai Chi Practice	3 ± 2
Max CSF Flow (cm/s)	6.66 ± 2.29
Net CSF Velocity (cm/s)	-1.18 ± 5.04
Heart Rate (bpm)	60.77 ± 6.23 (n=26)
Heart Amplitude	503.8 ± 51.1 (n=27)
Respiration Rate (breaths/min)	9.72 ± 1.79 (n=25)
Respiration Amplitude	607.4 ± 326.2 (n=25)
Plasma $A\beta_{42}$ (pg/ml)	350.8 ± 80.4 (n=27)
Plasma $A\beta_{40}$ (pg/ml)	30.5 ± 4.7 (n=27)
Plasma pTau ₂₁₇ (pg/ml)	0.11 ± 0.05 (n=27)



No significant association was observed between TCC and D^* , only with net aqueductal velocity



Relationships of cardio-respiratory factors with Tai Chi category (TCC). Longer Tai Chi practice was associated with lower respiratory amplitude (Figure 2B)



DISCUSSION

Tai Chi practice and CSF physiology

With longer Tai Chi practice, greater CSF moved into the brain than out but was not strongly associated with respiratory rate or amplitude.

Respiration and Cardiac physiology

Only decreased respiratory amplitude was associated with increased significantly with increased TCC .

Mediation analysis showed no indirect effect through respiration amplitude indicating that cardio-respiratory variables did not mediate the association between Tai Chi and net CSF velocity.

CONCLUSION

- Effects of Tai Chi were not strong in this study, but phase contrast MRI provided insight into CSF dynamics. Net CSF velocity was associated with longer Tai Chi practice.
- These observations follow other epidemiological studies showing no long-term effect of Tai Chi on respiration or cardiac physiology.

Clearance

CSF motion can only be interpreted indirectly in the context of clearance. In this work, There was no correlation between TCC and plasma biomarker of AD.

REFERENCES

- Yamada, S., Hiratsuka, S., Otani, T., Ii, S., Wada, S., Oshima, M., Nozaki, K., & Watanabe, Y. (2023). Usefulness of intravoxel incoherent motion MRI for visualizing slow cerebrospinal fluid motion. *Fluids and Barriers of the Central Nervous System*, 20, 16.
- Zare, F., Shakhmurova, G., Rizaev, J., Smerat, A., Abbood, R. S., Patil, V., & Kumar-Mishra, M. (2026). Sleep-dependent clearance of brain metabolites via the glymphatic system: Implications for Alzheimer's pathophysiology. *Brain and Behavior*, 16, e71374.
- Holmes, M. L., Manor, B., Hsieh, W. H., Hu, K., Lipsitz, L. A., & Li, L. (2015). Tai Chi training reduced coupling between respiration and postural control. *Neuroscience Letters*, 610, 60–65.
- Iliff, J. J., Wang, M., Liao, Y., Plogg, B. A., Peng, W., Gundersen, G. A., Benveniste, H., Vates, G. E., Deane, R., Goldman, S. A., Nagelhus, E. A., & Nedergaard, M. (2012). A paravascular pathway facilitates cerebrospinal fluid flow through the brain parenchyma and the clearance of interstitial solutes, including amyloid β . *Science Translational Medicine*, 4(147), 147ra111.