

Associations between CSF biomarkers and motor impairment measured by wearable sensors in cognitive decline

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Background and aims

The aim of this study was to investigate the associations between cerebrospinal fluid (CSF) biomarkers of neurodegeneration and quantitative motor features derived from standardized motor tests using wearable sensors in patients undergoing ascertainment for cognitive decline.

Materials and methods

25 patients (table 1) referred for cognitive evaluation underwent a comprehensive motor assessment protocol (2MWT, TUG, 360° and STS). Quantitative motor features were extracted from wearable inertial sensors. CSF samples were analysed for tTau, pTau₁₈₁, and Aβ₄₂/Aβ₄₀. Associations between CSF biomarkers and motor parameters were evaluated using partial Spearman correlations, adjusting for sex, age, disease duration, education, MoCA score, and clinical frailty scale.

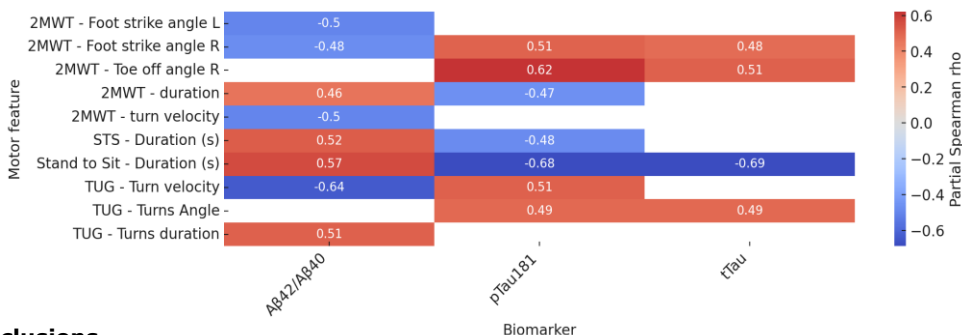
Results

After FDR correction, higher tTau and pTau₁₈₁ were linked to worse performance in TUG turning metrics and STS transitions, where higher levels corresponded to slower, more unstable turns and prolonged movements. Both tau markers were also negatively correlated with step cycle duration during the 2MWT, indicating a pathological pattern of shorter steps. In contrast, lower Aβ₄₂/Aβ₄₀ ratios were associated with longer double support times and reduced step velocity, reflecting early gait instability and balance deficits (figure 1). Overall, these results suggest that amyloid pathology manifests first through subtle impairments in stability, while tau-driven neurodegeneration drives more severe axial deficits, highlighting specific motor metrics as potential digital biomarkers of disease progression.

Table 1. Demographic characteristics of included participants.

Characteristic	Value
n	25
Sex (M/F)	8/17
Age	74.0 (71.0-81.0)
Disease duration (years)	5.0 (3.0-6.0)
Education (years)	10.0 (8.0-13.0)
MoCA	19.5 (17.7-23.7)
Clinical frailty scale	3.0 (2.0-3.0)
tTau (pg/mL)	565.0 (354.0-865.0)
pTau ₁₈₁ (pg/mL)	86.7 (47.7-129.3)
Aβ ₄₂ /Aβ ₄₀ ratio	0.051 (0.040-0.061)

Figure 1. Significant associations between motor task and biomarker. Colours indicate the direction and strength of the correlation.



Conclusions

These results indicate that CSF biomarkers of neurodegeneration and amyloid pathology are closely linked to sensor-derived motor impairments and highlight the potential value of integrating CSF and digital motor biomarkers in the evaluation of neurodegenerative disorders and supports further investigation in larger cohorts.

