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Agreement and Screening Performance of a Rapid Pressure-Based Balance Assessment

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Introduction

Objective balance assessment plays an important role in rehabilitation practice. However, conventional center-of-pressure–based systems often require prolonged testing time and specialized equipment, which may limit their clinical feasibility.

This study aimed to evaluate the validity and clinical applicability of a newly developed pressure-distribution–based balance assessment device capable of rapid evaluation within approximately 5 seconds by comparing its measurements with those obtained from a validated reference system.

Methods

A total of 20 adults (11 males and 9 females) underwent balance assessment in a hospital clinical setting. Balance performance was evaluated using the modified Clinical Test of Sensory Interaction on Balance (mCTSIB) under four standardized sensory conditions (firm surface with eyes open, firm surface with eyes closed, foam surface with eyes open, and foam surface with eyes closed) using a validated reference system (FRA 510S). The same participants were subsequently assessed using a newly developed ataxia mapping device that analyzes pressure distribution characteristics through a rapid measurement lasting approximately 5 seconds. Pearson correlation analysis and Bland–Altman plots were used to assess relationships and agreement between the two systems.

Receiver operating characteristic (ROC) analysis was performed using pressure asymmetry indices derived from the new device to determine its ability to identify balance instability defined based on high-difficulty conditions measured by the FRA 510S.

Results

The newly developed device demonstrated significant correlations with the reference system across balance assessment parameters (Table 1).

Bland–Altman analysis indicated acceptable agreement without significant systematic bias (Figure 1).

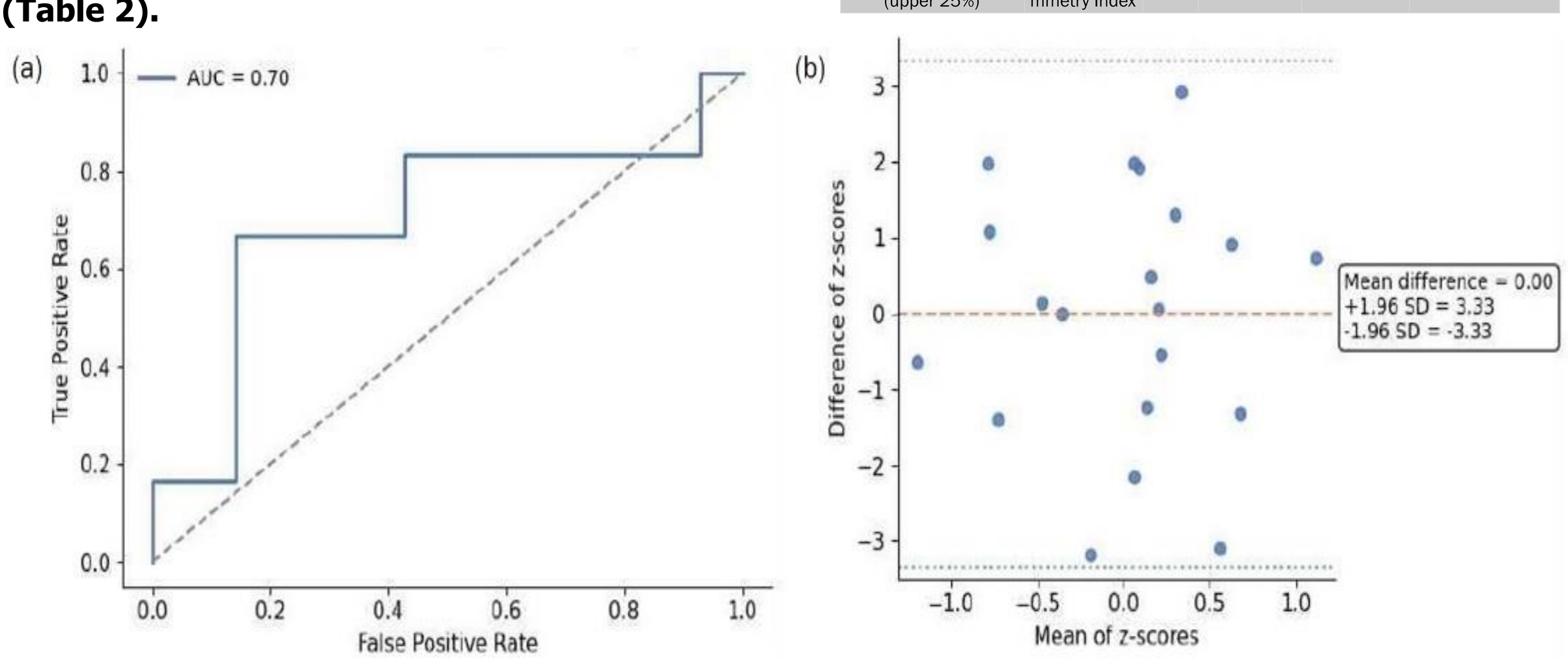
ROC analysis showed that pressure asymmetry indices derived from the rapid assessment were able to discriminate individuals with balance instability under challenging conditions, supporting its potential screening capability (Table 2).

Table 1. Convergent validity between FRA 510S sway index and Dynamic Balance pressure asymmetry-based index

FRA Condition	Pearson r (Pressure Asymmetry Index vs FRA sway)	p-value	Bland-Altman (LoA, z-score)
Condition 1 (EO, firm)	- 0.23	0.332	± 3.15
Condition 2 (EC, firm)	- 0.04	0.880	± 2.89
Condition 3 (EO, foam)	- 0.03	0.886	± 2.89
Condition 4 (EC, foam)	- 0.37	0.109	± 3.33

Table 2. Discriminative performance of the Dynamic Balance system for identifying balance instability

Reference standard	Predictor	AUC	Sensitivity	Specificity	Optimal cut-off
FRA 510S Condition 4 (upper 25%)	Pressure Asymmetry Index	0.70	0.67	0.86	≤ -30.4



(a) Receiver operating characteristic (ROC) curve demonstrating the discriminative performance of the Dynamic Balance system for identifying balance instability, using the FRA 510S mCTSIB Condition 4 (upper 25%) as the reference standard. The area under the curve (AUC) was 0.70.
(b) Bland–Altman plot showing the agreement between the FRA 510S sway index and the Pressure Asymmetry Index derived from the Dynamic Balance system under mCTSIB Condition 4. Data were standardized using z-scores. The mean difference was 0.00, and the 95% limits of agreement were ±3.33.

Fig 1. Discriminative performance and agreement between the Dynamic Balance System and FRA 510S.

Conclusion

The proposed device may serve as a complementary clinical tool by enabling rapid balance assessment within approximately 5 seconds while capturing spatial characteristics of balance control strategies. These findings suggest its potential utility as a practical and time-efficient balance screening tool in rehabilitation and exercise settings.