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AR-Based Functional Assessment and Its Association with Muscle and Pulmonary Function

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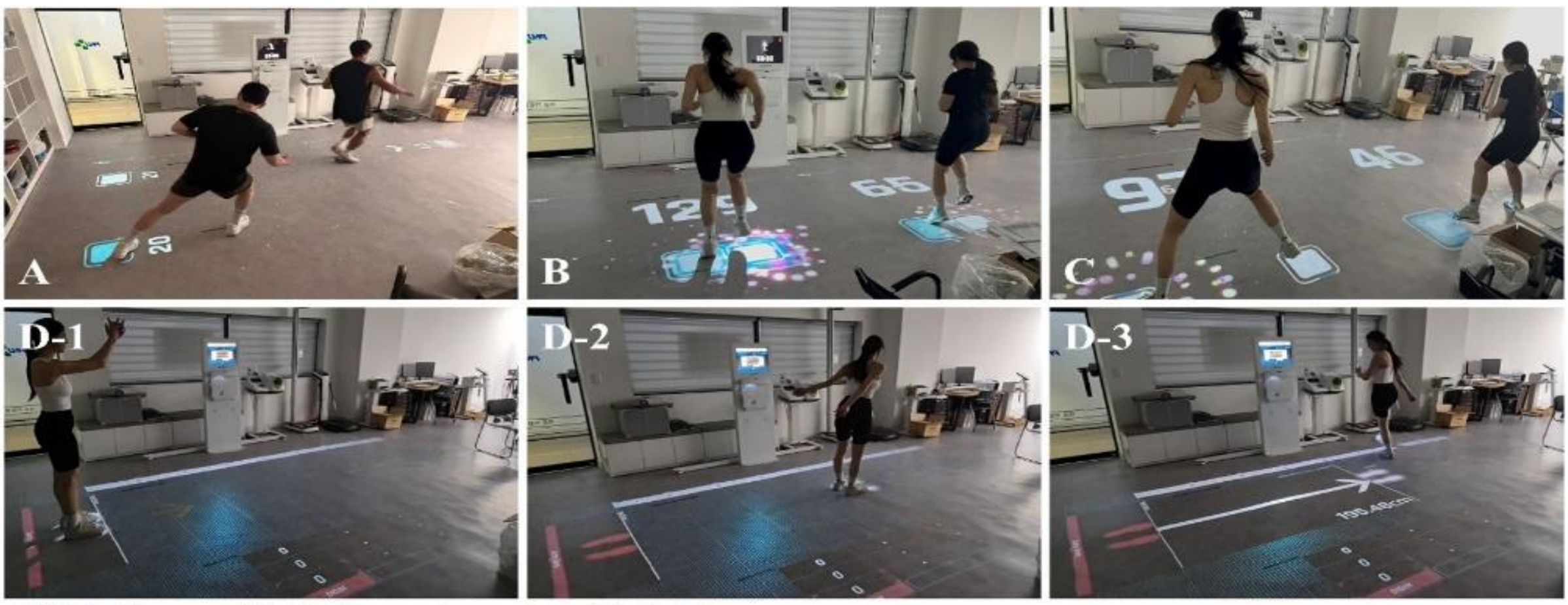
Introduction

The demand for quantitative and remote functional assessments has been growing with the development of digital healthcare technologies. However, most existing digital exercise platforms only provide exercise content and lack evidence linking their metrics with clinical standards. This study aimed to examine the clinical validity of an augmented reality (AR)-based indoor exercise platform (Didim) by analyzing correlations between its functional test results and standard clinical indicators such as hand grip strength, lower limb muscle mass, and pulmonary function.

Methods

Thirty healthy adults (15 men, 15 women; mean age 31.79 ± 5.52 years) participated in this study. Functional performance was assessed using the Didim platform, which employs LiDAR-based motion capture to provide real-time feedback and quantitative data. The platform included standing long jump, shuttle run, side jump, and on-the-spot running (Figure 1).

Standard clinical tests performed in the hospital setting included hand grip strength, skeletal muscle mass index (SMI), lower limb muscle mass (LMM), forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), and the 1-minute sit-to-stand test (1MSTST). All procedures were approved by the Institutional Review Board of our institution, and written informed consent was obtained from all participants. Pearson correlation analysis was performed after confirming normality.



(A) Shuttle run; (B) On-the-spot running; (C) Side jump;
(D-1) Standing long jump – ready position; (D-2) post-jump landing; (D-3) automatic distance measurement.

Fig 1. Physical Performance Tests Using the AR-Based Platform

Results

Didim standing long jump showed significant positive correlations with hand grip strength (r=0.844, $p<0.001$), SMI (r=0.801, $p<0.001$), LMM (r=0.786, $p<0.001$), FVC (r=0.757, $p<0.001$), FEV_1 (r=0.637, $p<0.001$), MIP (r=0.681, $p<0.001$), MEP (r=0.527, $p=0.003$), and 1MSTST (r=0.381, $p=0.038$). Didim shuttle run also correlated significantly with MIP (r=0.457, $p= 0.011$), MEP (r=0.398, $p=0.029$), hand grip strength (r=0.432, $p=0.017$), and 1MSTST (r=0.379, $p=0.039$) (Table 1).

In contrast, side jump showed no significant correlations with clinical measures, and on-the-spot running showed only weak non-significant trends.

r = Pearson correlation coefficient; P = significance level; P < 0.05; * P < 0.01; FTSST, Five Times Sit-to-Stand Test; 1MSTST, 1-minute Sit-to-Stand Test; FVC, Forced Vital Capacity; FEV_1, Forced Expiratory Volume in 1 second; MIP, Maximal Inspiratory Pressure; MEP, Maximal Expiratory Pressure; SMI, Skeletal Muscle Mass Index; SMM, Skeletal Muscle Mass; LMM, Lower Limb Muscle Mass.

Table 1. Pearson Correlations Between AR-Based Functional Test Items and Clinical Measures

	Shuttle Run Distance		On-the-spot running		Side Jump		Standing Long Jump	
	r	p	r	p	r	p	r	p
FTSST (sec)	-0.327	0.078	-0.096	0.614	-0.101	0.596	-0.157	0.480
1MSTST (number)	0.379*	0.039	0.250	0.183	-0.086	0.652	0.381*	0.038
FVC (L)	0.334	0.071	0.313	0.092	-0.086	0.651	0.757**	<0.001
FEV_1 (L)	0.189	0.317	0.248	0.187	-0.143	0.452	0.637**	<0.001
FEV_1/FVC	-0.393*	0.032	-0.257	0.171	-0.157	0.406	-0.416*	0.022
FVC%	0.146	0.441	0.390*	0.033	-0.168	0.375	0.535**	0.002
FEV_1%	0.113	0.553	0.266	0.156	-0.221	0.241	0.499**	0.005
MIP (cmH_2O)	0.457*	0.011	0.141	0.459	-0.055	0.771	0.681**	<0.001
MEP (cmH_2O)	0.398*	0.029	0.141	0.459	0.057	0.764	0.527**	0.003
Hand grip strength (kg)	0.432*	0.017	0.247	0.188	-0.021	0.914	0.844**	<0.001
SMI (kg/m^2)	0.277	0.139	0.244	0.194	0.056	0.768	0.801**	<0.001
SMM (kg)	0.254	0.176	0.191	0.313	0.017	0.931	0.841**	<0.001
LMM (kg)	0.230	0.221	0.173	0.360	0.041	0.828	0.786**	<0.001
Biodex peak (N·m)	0.197	0.296	0.080	0.673	-0.010	0.957	0.685**	<0.001

Conclusion

The Didim AR-based functional assessment platform demonstrated significant associations between its metrics and established clinical indicators of muscle strength, muscle mass, and pulmonary function in healthy adults. Standing long jump served as a comprehensive marker reflecting both muscular and respiratory functions, while shuttle run emerged as a feasible alternative in populations with difficulty performing explosive jumps. These findings support the clinical validity and potential application of AR-based digital platforms as adjunct tools for functional assessment in rehabilitation and health promotion.