

Reliability and Validity of Virtual Box & Block Test in Healthy Adults and Patients with Stroke

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Purpose

- ✓ The study aimed to investigate reliability and validity of the virtual reality Box & Block Test (VR BBT) in healthy adults and patients with stroke.

Methods

Participants

Patients with stroke

- **Inclusion Criteria**
 - Adults aged 19 years or older
 - Patients diagnosed with ischemic or hemorrhagic stroke
 - Patients capable of maintaining stable sitting posture
- **Exclusion Criteria**
 - Severe cognitive impairment (MMSE-K ≤ 10)
 - Upper extremity impairment caused by conditions other than stroke
 - History of severe dizziness or uncontrolled epilepsy

Healthy adults

- **Inclusion Criteria**
 - Adults aged 19 years or older
 - Individuals who voluntarily agree to participate in the study
- **Exclusion Criteria**
 - Individuals with neurological or orthopedic disorders affecting upper extremity motor function
 - Individuals with any other comorbidities deemed by the researcher to hinder participation in the study

Assessments

BBT



VR BBT



Physical interaction

Virtual objects (hand and blocks) follow the laws of real-world physics.



No physical interaction

The virtual hand does not physically interact with blocks; it can pass through blocks but cannot pass through the box.



- Participants performed each of the three test versions in a randomized order.
- Each hand was tested twice for each test condition.

Results

Characteristics of participants (N=48)

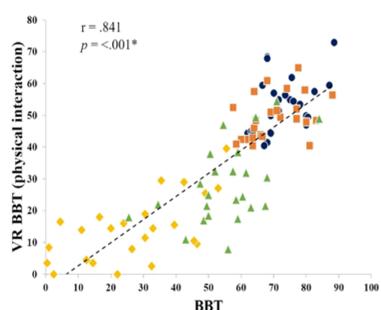
	Patient with stroke (n=24)	Healthy adults (n=24)
Male/female (n)	9/15	16/8
Age (yr)	55.63 ± 14.10	43.75 ± 8.29
Disease duration (mo)	64.95 ± 77.21	-
Mini-mental state examination - Korean	27.63 ± 3.63	-
Fugl-Meyer Assessment – upper extremity	47.25 ± 10.97	-
Type of lesion (ischemic/hemorrhagic)	10/14	-
Side of lesion (right/left)	13/11	-

Performance on BBT and VR BBT (N=48)

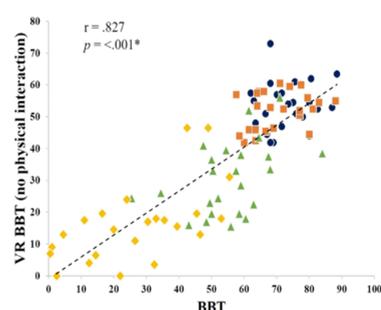
		Patient with stroke (n=24)		Healthy adults (n=24)
		Unaffected; dominant hand	Affected; non-dominant hand	
Box & Block Test	Unaffected; dominant hand	55.65 ± 12.04 [range: 25.5 – 84.0]	73.06 ± 7.33 [range: 62.0 – 88.5]	
	Affected; non-dominant hand	27.04 ± 16.88 [range: 0.0 – 55.5]	70.27 ± 8.49 [range: 57.5 – 88.0]	
Virtual reality Box & Block test	Physical interaction	Unaffected; dominant hand	28.40 ± 12.44 [range: 8.0 - 54.5]	53.69 ± 8.62 [range: 40.5 – 73.0]
		Affected; non-dominant hand	14.19 ± 10.24 [range: 0.0 - 39.5]	49.60 ± 6.97 [range: 40.5 - 65.0]
	No physical interaction	Unaffected; dominant hand	30.69 ± 11.29 [range: 15.5 – 56.0]	53.21 ± 7.72 [range: 42.0 – 73.0]
		Affected; non-dominant hand	16.21 ± 11.92 [range: 0.0 – 46.5]	51.96 ± 5.94 [range: 42.0 – 60.5]

Correlation between BBT and VR BBT

(A) VR BBT (physical interaction)



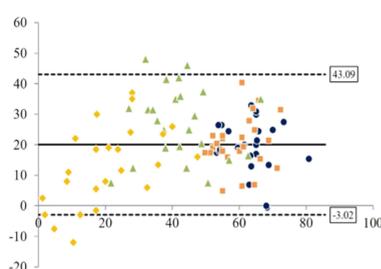
(B) VR BBT (no physical interaction)



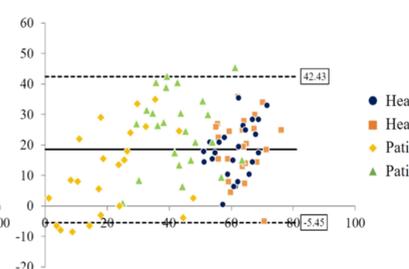
● Healthy adults – dominant hand
 ■ Healthy adults – non-dominant hand
 ◆ Patients with stroke – affected hand
 ▲ Patients with stroke – unaffected hand
 --- Line of best fit

Bland–Altman plots between the BBT and VR BBT

(A) VR BBT (physical interaction)



(B) VR BBT (no physical interaction)



● Healthy adults – dominant hand
 ■ Healthy adults – non-dominant hand
 ◆ Patients with stroke – affected hand
 ▲ Patients with stroke – unaffected hand

Reliability and validity of BBT and VR BBT

Test-retest reliability of BBT and VR BBT (N=48)

	BBT	VR BBT	
		Physical interaction	No physical interaction
ICC (95% CI)	.982 (.973-.988)	.940 (.912-.960)	.943 (.916-.962)

Concurrent validity of BBT and VR BBT with the FMA-UE in patients with stroke (N=24)

	BBT	VR BBT	
		Physical interaction	No physical interaction
r (p-value)	.839 (<.001)	.657 (<.001)	.676 (<.001)

Movement parameters from the VR BBT in patients with stroke

	Physical interaction					No physical interaction				
	Unaffected side	Affected side	p	r with FMA-UE	p	Unaffected side	Affected side	p	r with FMA-UE	p
Distance (m)	0.19983 ± 0.06115	0.21571 ± 0.07084	.055	-.382	.079	0.20057 ± 0.05241	0.22693 ± 0.06689	.033*	-.466	.029*
Distance-max (m)	0.41455 ± 0.07610	0.39256 ± 0.06219	.733	-.477	.025*	0.33806 ± 0.08241	0.37776 ± 0.11077	.120	-.438	.041*
Speed (m/s)	0.27149 ± 0.14132	0.18386 ± 0.08880	<.001*	.487	.022*	0.28164 ± 0.08194	0.21256 ± 0.07665	<.001*	.454	.034*
Acceleration magnitude (m/s ²)	0.16698 ± 1.51791	0.13310 ± 0.83288	.300	.193	.390	0.14609 ± 0.08632	0.13155 ± 0.08664	.578	.319	.148

Conclusion

- ✓ The VR BBT demonstrated strong reliability and validity despite differences in performance counts compared to BBT.
- ✓ In patients with stroke, the affected hand showed greater movement distance but lower speed, indicating inefficient motor control. These parameters were significantly associated with FMA-UE, suggesting their potential as objective markers of upper limb motor impairment.
- ✓ These findings suggest that the VR-BBT could serve as a complementary tool for motor function assessment, with potential applications in tele-rehabilitation and virtual reality-based rehabilitation.

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