P-4

Effect of a Multi-Sensor-Based Digital Intervention on Frailty in Community-Dwelling Older Adults

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Introduction

■ **Frailty** is defined as a reduced physiologic reserve vulnerable to external stressors.

■ It is associated with increased risks of disability, hospitalization, falls, morbidity and mortality in older adults.

■ Current digital health interventions are limited to single-sensor modalities and do not provide comprehensive exercise programs.

■ Therefore, We developed **a multi-sensor-based digital device for structured multicomponent exercise and evaluated its effects on physical function and frailty**

Methods

■ **Study population**

- Community-dwelling older adults with frailty or pre-frailty, total 61 (experimental 30, control 31)
- Control group → routine multicomponent exercise program
- Experimental group → the same program, with certain sessions delivered using a multi-sensor–based digital device

■ **Assessment of physical function**

- Short Physical Performance Battery (SPPB)
- Arm-Curl test
- Apley scratch test
- Soda-Pop test

■ **Assessment of Frailty status and patient-reported outcomes**

- Korean version of the FRAIL scale (K-FRAIL)
- Physical Functioning (PF) scale
- EuroQol Visual Analogue Scale (EQ-VAS)

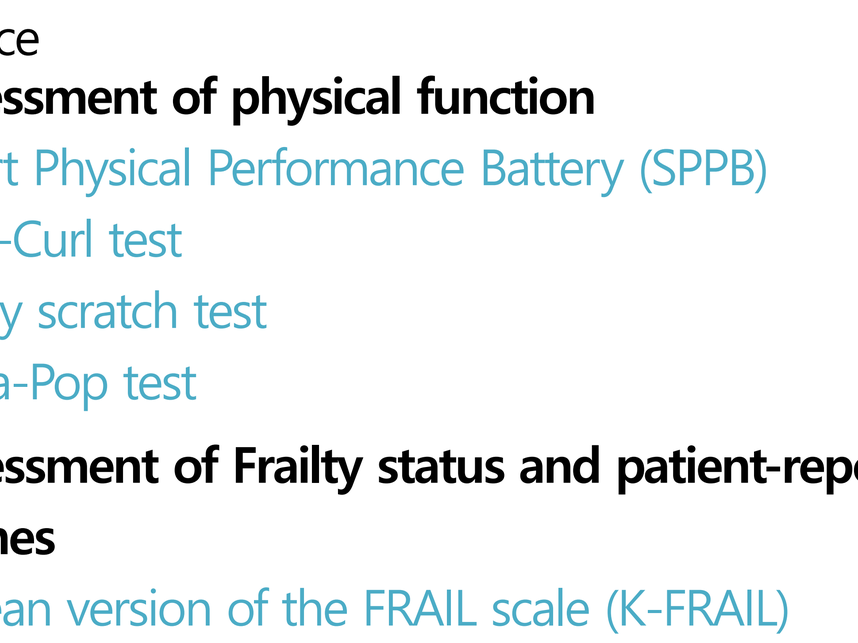

Fig 1. Multi-sensor based smard device (A: Care-Vision, B: Care-Grip, C: Care-Pad)

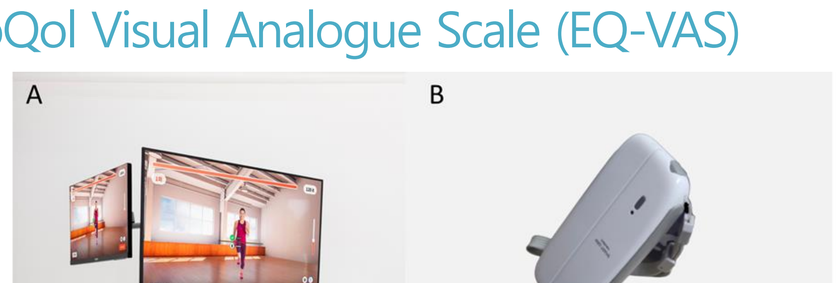

Fig 2. Some of the programs of multi-sensor based smart device designed to slow frailty progression

Fig 3. Participants performing exercise using the multi-sensor-based smart device

Results

Table 1. Baseline characteristics of participants

	Control (N=31)	Experimental (N=30)	Total (N=61)	p-value
Age (years)	82.1±7.2	82.9±7.8	82.5±7.5	0.68
Sex (female)	22 (71%)	21 (70%)	43 (70.5%)	0.93
BMI (kg/m^2)	24.3±4.2	22.0±3.6	23.2±4.0	<0.05
Education level (years)	5.1±5.4	4.3±4.7	4.7±5.0	0.57
K-FRAIL (score)	1.8±1.3	1.9±1.3	1.9±1.3	0.93
PF-mobility (score)	54.6±30.4	56.7±31.0	55.6±30.5	0.80
PF-self-care (score)	65.2±27.7	56.9±36.4	61.1±32.3	0.32
PF-total (score)	59.9±26.2	56.8±32.9	58.4±29.5	0.68
EQ-VAS (score)	66.4±21.6	55.3±22.7	61.0±22.7	0.06

* BMI, body mass index; K-FRAIL, korean version of the FRAIL scale; PF, physical functioning scale; EQ-VAS, EuroQol Visual Analogue Scale

✓ generally comparable between groups, including age, sex, education level, frailty status, and physical function measures

Table 2. Comparison of changes in objective physical function

	Control (N=31)			Experimental (N=30)		
	Pre	Post	p-value btw pre-post	Pre	Post	p-value btw pre-post
Arm-Curl (times)	13.6±4.6	13.6±4.7	0.94	10.1±5.1[b]	11.8±5.2	< 0.01
Shoulder (cm)						
Right	-31.0±22.6	-36.3±16.6	0.21	-27.3±16.9	-31.7±15.0	< 0.05
Left	-35.8±13.6	-39.4±16.1	0.10	-33.6±18.1	-33.0±16.8	0.75
Soda-pop (sec)	24.9±11.4	25.8±10.9	0.42	24.5±11.2	22.0±8.7	0.07
SPPB						
Balance (score)	2.9±1.3	2.5±1.5	< 0.05	2.3±1.6	2.7±1.3	0.10
5STS (sec)	19.1±16.8	19.8±16.1	0.83	28.1±20.0	23.2±13.8	0.18
Walking speed (sec)	9.6±6.2	10.6±5.0	0.34	10.4±6.9	8.8±3.5	0.17
Composite score (score)	7.5±3.1	6.8±3.0	<0.05	6.0±3.2	6.3±2.6	0.49

** Superscripts (a, b, c) indicate statistically significant differences in baseline (pre-intervention) values between the control and experimental groups (a: p < 0.05; b: p < 0.01; c: p < 0.001).*
* Shoulder, Hands behind the back test; SPPB, Short Physical Performance Battery; 5STS, 5 times sit to stand test

✓ **Upper extremity strength (arm curl)**
- Significantly improved in the experimental group
- No significant change in the control group

✓ **SPPB balance scores and composite scores**
- Significantly declined in the control group, while these measures were maintained in the experimental group

Table 3. Comparison of changes in self-reported physical function and frailty

	Control (N=31)			Experimental (N=30)		
	Pre	Post	p-value btw pre-post	Pre	Post	p-value btw pre-post
EQ-VAS (score)	66.4±21.6	55.0±25.7	<0.05	55.3±22.7	60.5±25.8	0.32
K-FRAIL	1.84±1.29	2.19±1.22	0.07	1.87±1.31	1.87±1.17	1.00
PF-mobility	54.6±30.4	44.3±26.9	<0.05	56.7±31.0	59.1±31.4	0.52
PF-selfcare	65.2±27.7	44.1±29.6	<0.001	56.9±36.4	45.1±29.5	<0.05
PF-total	59.9±26.2	44.2±27.2	<0.001	60.5±25.8	52.1±28.9	0.21

** Superscripts (a, b, c) indicate statistically significant differences in baseline (pre-intervention) values between the control and experimental groups (a: p < 0.05; b: p < 0.01; c: p < 0.001).*

* EQ-VAS, EuroQol Visual Analogue Scale; K-FRAIL, korean version of the FRAIL scale; PF, physical functioning scale

✓ **EQ-VAS, PF-mobility, and PF-total scores**
- Significantly decreased in the control group
- No significant deterioration was observed in the experimental group

✓ **K-FRAIL scores**
- Stable in the experimental group
- Tendency to worsen in the control group

Conclusion

- The multi-sensor based digital intervention showed comparable or modest improvements in frailty status and physical performance compared with the control group
- These findings suggest that sensor-integrated digital exercise may help maintain or support functional outcomes in community-dwelling older adults with frailty

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