

Title: Effects of Virtual Reality Game Training on Upper extremity Motor Recovery in Stroke Survivors: A Pilot Randomized-Control Trial

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Results

Participant Flow

During recruitment, 41 participants initially enrolled, but 11 (26.8%) could not begin participation due to practical barriers, which have been highlighted in the Consort participant recruitment and randomization flow diagram (Figure 2). This left us with 30 participants (18 males, 12 females) who were randomized to either the VRG group (n=15; 9 males, 6 females) or the CPT group (n=15; 9 males, 6 females). All 30 participants completed the study as shown in Figure 2.

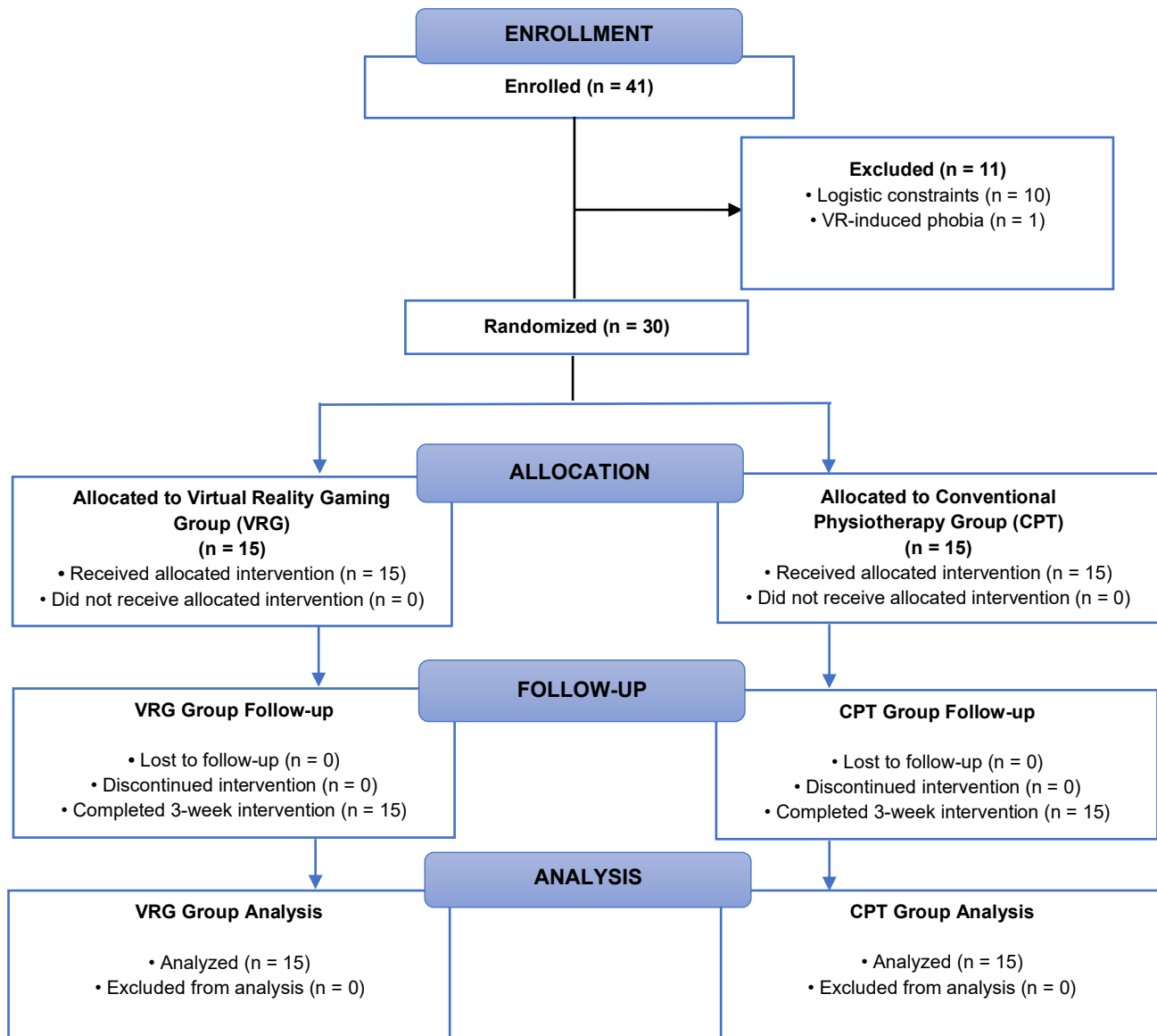


Figure 2: Consort participant recruitment and randomisation flow diagram.

Adverse Effect Study Report Protocol

We recorded no serious adverse health events during the study and maintained strict data confidentiality throughout the study period. One participant experienced VR-induced phobia during initial exposure, leading to immediate session discontinuation, study withdrawal and subsequent follow-up.

Outcome Measures

We assessed all participants at baseline and study completion using four validated instruments. These included the Fugl-Meyer Assessment for Upper Extremity (FMA-UE), which was the primary outcome measure, and Upper Extremity Function Index (UEFI), Wolf Motor Function Test (WMFT) and Medical Research Council Scale (MRC) as secondary outcome measures.

Primary Outcome Measures

Fugl-Meyer Assessment for Upper extremity (FMA-UE):

FMA-UE was used to measure motor impairment by assessing motor function, hand function, grasp, coordination and speed, sensation (light touch, proprioception) and joint pain. FMA-UE has been found to have excellent scores in validity and reliability²⁹.

Upper Extremity Functional Index (UEFI):

UEFI was used to measure functional impairment by assessing the upper extremity ADLs and Instrumental Activities of Daily Living (IADLs) through 20 items covering basic and instrumental activities of daily living³⁰.

Secondary Outcomes Measures

Wolf Motor Function Test (WMFT):

WMFT was used to measure upper extremity motor function by assessing motor performance of the affected upper extremity through two strength measurements and 15 functional tasks, including- lifting, reaching and retrieving, grasp (3-jaw chuck grasp, pincer grasp) and grip strength³¹.

Medical Research Council (MRC) Scale:

MRC was used to assess muscle strength in all the muscle groups of the upper extremity. MRC has been found to have excellent scores in reliability and Validity³².

Data Distribution

Normality assessment of the combined dataset (n=30) using the Shapiro-Wilk test revealed heterogeneous distributions across variables. Several outcome scores demonstrated normal distributions, while others exhibited non-normal distributions. This led us to modify the analytical approach to adopt non-parametric statistics.

Baseline Characteristics

Baseline demographic and clinical characteristics for participants in both groups are presented in Table 1. We calculated median values for continuous variables (age, weight, height, and post-stroke duration). Results from Mann-Whitney U analyses showed homogeneity between both groups across all variables.

Table 1: Baseline Characteristics of Participants in VRG and CPT Groups

	VRG Group		CPT Group		
VARIABLE	Median	IQR	Median	IQR	P-value
AGE (Years)	70.0	14	65.0	24	0.453
Body Mass (Kg)	161.0	7.0	66.8	24.8	0.901
Height (Cm)	65.2	26.1	162.0	9.0	0.662
Post-Stroke duration (Months)	3.0	26.0	3.0	34.0	0.848

*Statistically significant at $p < 0.05$; Kg- Kilogram(s); Cm- Centimetre(s); VRG- Virtual Reality Gaming group; CPT- Conventional Physiotherapy group.

Within-Group Comparison of Outcomes

Virtual Reality Gaming Group (VRG)

Wilcoxon signed-rank test analyses revealed statistically significant pre- to post-intervention changes in motor impairment ($p = 0.001$), FMA-UE motor function ($p = 0.001$), coordination ($p = 0.005$), joint pain ($p = 0.018$), hand function ($p = 0.039$), grasp ($p = 0.038$), muscle strength ($p = 0.001$), functional impairment ($p = 0.001$) and WMFT motor function ($p = 0.002$) outcome scores. No significant changes were observed for sensation ($p = 0.180$) or passive joint motion ($p = 0.1000$) outcome scores.

Conventional Physiotherapy Group

On comparison of pre- to post-intervention values, statistically significant changes were demonstrated for motor impairment ($p= 0.007$), FMA-UE motor function ($p= 0.007$), muscle strength ($p= 0.007$), functional impairment ($p= 0.011$) and WMFT motor function ($p= 0.007$) outcome scores. No significant changes were observed for coordination ($p= 0.157$), passive joint motion ($p= 1.000$), joint pain ($p= 1.000$), hand function ($p= 0.157$), or grasp ($p= 0.102$) outcome scores.

Between-Group Comparison of Outcomes

Mann-Whitney U test analyses showed statistically significant between group improvements favoring the VR intervention for motor impairment ($p<0.001$), FMA-UE motor function ($p= 0.005$), coordination ($p= 0.001$), joint pain ($p= 0.003$), muscle strength ($p< 0.001$), functional impairment ($p< 0.001$), and WMFT motor function ($p= 0.004$) outcome scores. No significant between-group differences were observed for sensation ($p= 0.150$), passive joint motion ($p= 0.150$), hand function ($p= 0.169$) or grasp ($p= 0.407$) outcome scores.

Correlation Analyses

Pearson's correlation was used to explore associations within each group. Our analyses revealed different patterns of relationships between post-stroke duration and upper extremity outcomes across treatment groups.

Virtual Reality Gaming Group (VRG)

In the VRG Group, post-stroke duration was not significantly correlated with motor impairment ($r = -.474$, $p = .074$), functional impairment ($r = -.371$, $p = .174$), or WMFT motor function ($r = -.180$, $p = .521$) outcomes. There was no significant correlation between motor impairment and functional impairment outcomes in the VR group ($r = 0.043$, $p = 0.880$). However, there was a moderate positive correlation between muscle strength and functional impairment ($r = 0.586$, $p = 0.022$), which was statistically significant.

Conventional Physiotherapy Group (CPT)

In contrast, the Conventional Physiotherapy Group showed significant negative correlations between post-stroke duration and motor impairment ($r = -.595$, $p = .019$), functional impairment ($r = -.539$, $p = .038$), and WMFT Motor Function ($r = -.668$, $p = .007$) outcome scores respectively. There was also a significant correlation between motor impairment and functional impairment ($r = .663$, $p = .007$) outcomes. Furthermore, there was a moderate positive correlation between muscle strength and functional impairment ($r = 0.581$, $p = 0.023$), which was statistically significant.