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"Effect Of Eye-Hand Coordination Device To Enhance Co-Ordination In Upper Limb Stroke Survivors"

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Abstract:
Background*: Stroke often results in significant motor function deficits, particularly in the upper limbs, severely impairing daily activities. Traditional neuro-rehabilitation methods have shown some effectiveness, but there remains a need for more innovative interventions. Eye-hand coordination, essential for tasks such as eating, dressing, and writing, is often overlooked in rehabilitation for neurologically impaired patients. This study investigates the impact of eye-hand coordination devices on improving coordination in upper limb stroke survivors.*
Results*: Significant improvements were observed in both groups, with more pronounced gains in Group A. FMA-UE scores in Group A improved from 35.08 ± 5.68 to 48.60 ± 6.35 (p = 0.0001), and NCT scores increased from 13.76 ± 2.59 to 21.68 ± 2.67 (p = 0.0001). Group B also showed improvements, but to a lesser extent.*
Key Word*: Eye-Hand Coordination, Stroke Rehabilitation, Upper Limb Motor Function, Neuro-Rehabilitation, Fugl-Meyer Assessment, Non-Equilibrium Coordination Test, Experimental Therapy, Conventional Therapy.*

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I. Introduction

Eye-hand coordination is frequently affected by strokes, making daily tasks challenging. The site of the stroke and its intensity determine how much disruption occurs. The integration of visual and motor information might be hindered by damage to the brain regions called the primary motor cortex, cerebellum, or parietal lobes that are in charge of motor control. Therefore, stroke survivors may have difficulty with tasks involving precise hand movements, like reaching, gripping, and handling objects [(1)] .Thus, improving hand-eye coordination is a primary objective in stroke recovery. Programs for rehabilitation use a variety of treatment approaches to try to enhance this coordination. To improve hand-eye coordination, methods like visual motor training, task-specific training, and assistive technology are frequently used. By allowing the damaged limb to be used in meaningful circumstances, task-specific training encourages functional recovery through practice of activities that replicate real life tasks [(2)]

II. Material And Methods

A comparative study was conducted at Pravar Institute of Medical Sciences over six months. Fifty MCA stroke survivors were selected and divided into two groups: Group A (Experimental Therapy) and Group B (Conventional Therapy). Group A underwent therapy with eye-hand coordination devices, while Group B received traditional neuro-rehabilitation exercises. Participants were assessed using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE) and the Non-Equilibrium Coordination Test (NCT). Data analysis was performed using SPSS software version 20, with a p-value set at $p < 0.05$

Study Design: Comparative study
Study Location: Study will be conducted in the out-patient department of Neuro physiotherapy department and department of medicine
Study Duration: August 2024 to February 2025
Sample size: 50 stroke survivours

Inclusion criteria:
1. Both male and female population
2. Age between 40- 60 years
3. Diagnosed case of cerebrovascular accident

4. Individuals willing to sign the consent

Exclusion criteria:
1. Disoriented individuals
2. Brain surgery due to any other reason

Procedure methodology
1)Study design will be prepared prior to commencement of the study and ethical approval from IEC will be taken at Dr. APJ Abdul Kalam College Of Physiotherapy.
2) Send approval for randomized control trial.
3) Samples will be identified according to exclusion and inclusion criteria
4) Entire process will be explained to the sample and a written consent will be taken.
5) The individuals will be divided into 2 groups FRENKELS EXE
6) Group A will have 25 participants receiving Conventional treatment.
7) Duration – 4 weeks, 4 days per week and treartment duration - 30 to 40 mins
8) Group B will have 25 participants receiving Experimental treatment.
• GROUP B: CONVENTIONAL THERAPY
• Participants will be assessed for sensitivity.
• Participants will be explained about the procedure.
• FRENKELS EXERCISES for upper extremity
• Target practice
• Wall ball bounce
GROUP A: EXPRIMENTAL THERAPY
• Eye hand coordination device – participant will be in sitting position and is asked to hold the object of 2cm,3cm and as such.
• Therapist will demonstrate the activity, the patient will be handed the hand piece and then asked to move from starting position to end position.

Statistical analysis

Analysis of raw data was done using SPSS software 20 version (IBM SPSS Statistics Inc Chicago, Illinosis USA). The p value for statistical analysis was set at $p < 0.05$ with a confidence interval of 95%. Within the group comparison demonstrated that data is normally distributed checked by Shapiro wilk test, so parametric test were applied for the statistical analysis. The Paired t test was done for intragroup analysis of both the groups where Pre and Post value of group A and group B were analyzed separately for determining significant difference in outcome measures (FMA-UE, Non Equilibrium Coordination Test {NCT}) whereas unpaired t test was run for intergroup analysis where difference of pre and post of group A was compared with difference of pre and post of group B for evaluating the hypothesis.

III. Result

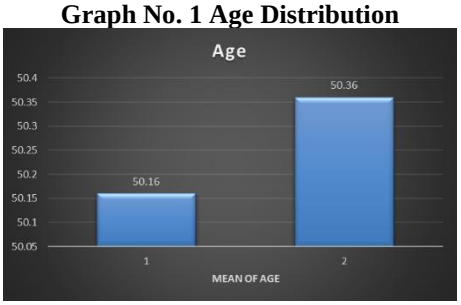
Table No. 1 Baseline Demographic Data

Variables	Group A	Group B
Age	**50.1600 ± 6.05310**	**50.3600 ± 6.27083**
Gender		
• Male	14	18
• Female	11	7

Table No. 1.1 Age Distribution

Groups	Mean ± SD
Group A	**50.1600 ± 6.05310**
Group B	**50.3600 ± 6.27083**

Graph No. 1 Age Distribution



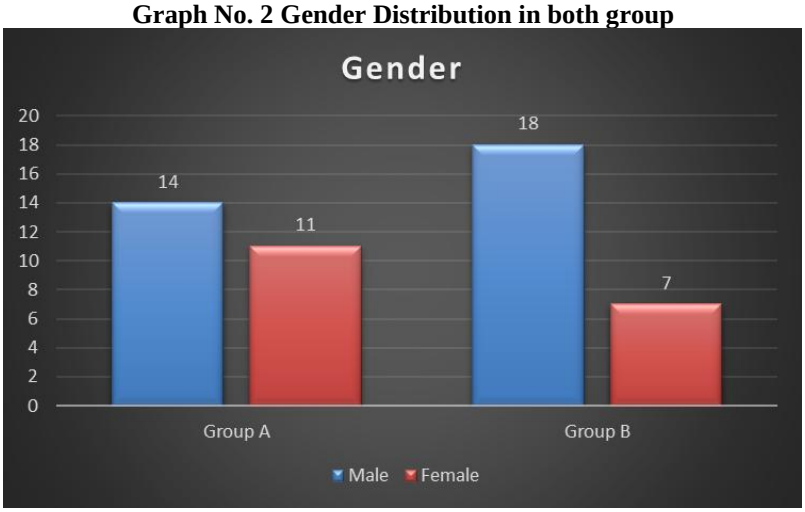
Interpretation:

The average age of Group A (experimental group neuro-rehabilitation) is 50.1600 ± 6.05310 years and Group B (Conventional neuro-rehabilitation) 50.3600 ± 6.27083 years

Table No. 1.2 Gender Distribution in both groups

Groups	Male	Female
Group A	14	11
Group B	18	7

Graph No. 2 Gender Distribution in both group



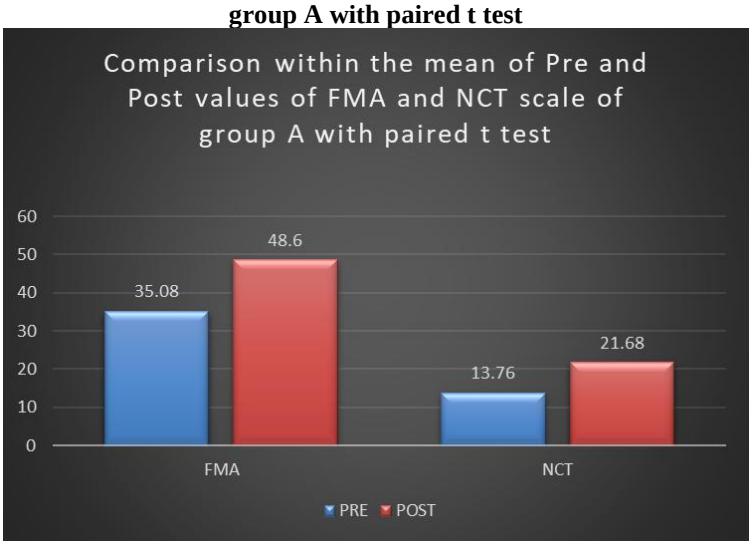
INTERPRETATION:

There were 14 males and 11 females in Group A Experimental Therapy who received and in group B there were 18 males and 7 females who received conventional neuro-rehabilitation therapy.

Table No. 1.3 Comparison within the mean of Pre and Post values of FMA and NCT scale of group A with paired t test

Group A	Assessment	Mean ± SD	Paired 't' test value	p- value	Significance
FMA	PRE	35.0800 ±5.67832	-70.224	0.0001	significant
	POST	48.6000 ±6.35085			
NCT	PRE	13.7600± 2.58650	-99.000	0.0001	significant
	POST	21.6800 ±2.67270			

Graph No. 3 Analysis of comparison within the mean of Pre and Post values of FMA and NCT scale of group A with paired t test



Graph No. 3 Comparison within the mean of Pre and Post values of FMA and NCT scale of group A with paired t test

Interpretation:

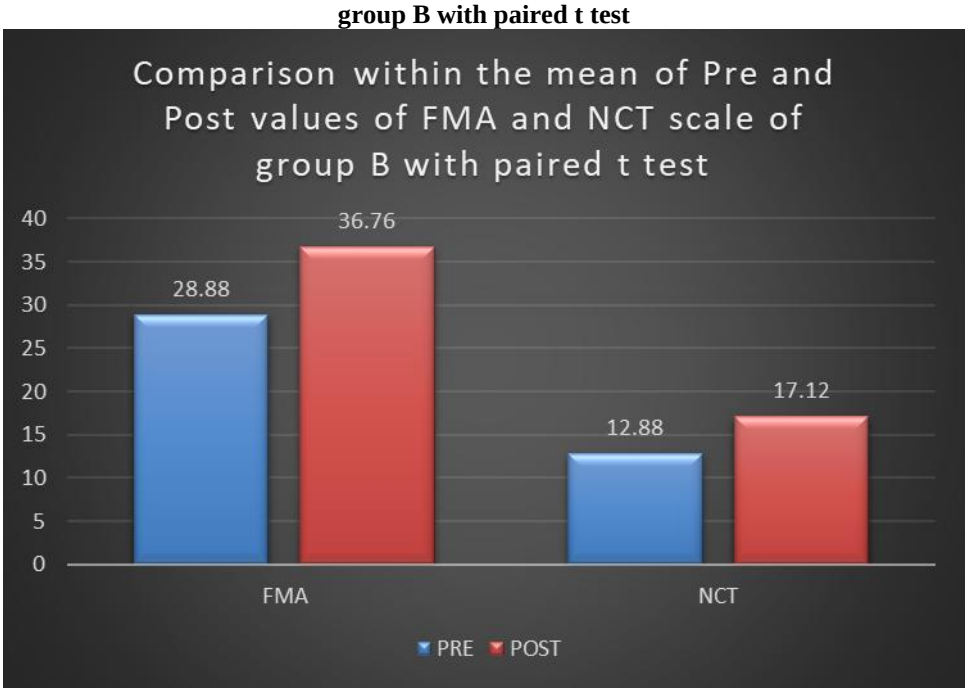
From Table no. 3 and Graph 3 we can conclude that post value of Group A has increased from 35.0800 ±5.67832 to 48.6000±6.35085 , with P= 0.0001, which is less than the set p value of 0.05, showing extremely significant improvement in group A in FMA-UE scale

Also, in post value of of group A has increased from 13.7600± 2.58650 to 21.6800±2.67270 , with P= 0.0001, which is less than the set p value of 0.05, showing extremely significant improvement in group A in NCT scale

Table 1.4 comparison within the mean of Pre and Post values of FMA and NCT scale of group B with paired t test

Group A	Assessment	Mean ± SD	Paired 't' test value	p- value	Significance
FMA	PRE	28.8800± 4.88467	-118.795	0.0001	significant
	POST	36.7600± 5.03554			
NCT	PRE	12.8800± 2.50533	-20.152	0.0001	significant
	POST	17.1200± 2.45493			

Graph No. 4 Analysis of comparison within the mean of Pre and Post values of FMA and NCT scale of group B with paired t test



Interpretation:

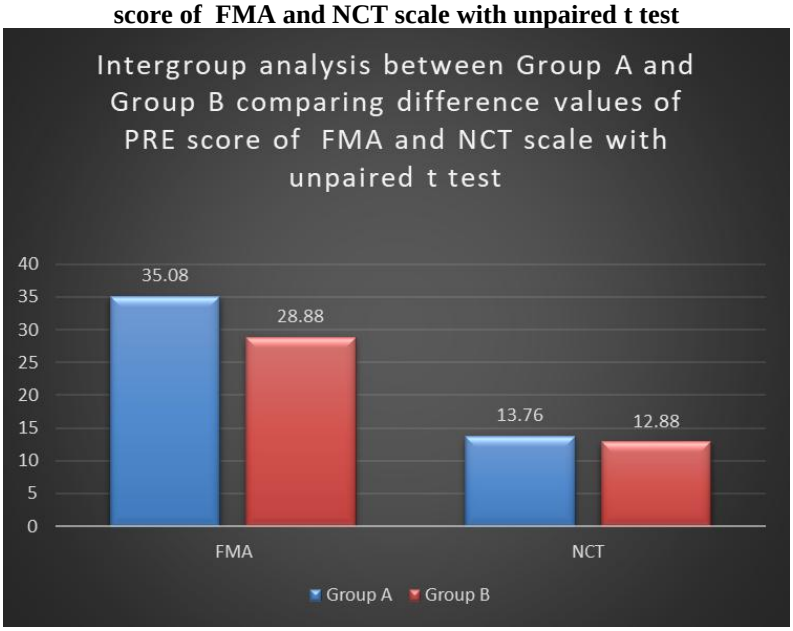
From Table no. 4 and Graph 4 we can conclude that post value of Group B has increased from28.8800±4.88467 To 36.7600± 5.03554 , with P=0.001, which is less than the set p value of 0.05, showing very significant improvement in group B in FMA-UE

Also, In NCT the post value of group B has increased from 12.8800±2.50533 to 17.1200±2.45493, with P= 0.0001, which is less than the set p value of 0.05, showing extremely significant improvement in group B

Table No. 1.5 Intergroup analysis between Group A and Group B comparing difference values of PRE score of FMA and NCT scale with unpaired t test

	Group	Mean ± SD of difference	Unpaired 't' test value	P- value	Significance
FMA	Group A	**35.0800 ±5.67832**	**4.139**	0.0001	extremely significant
	Group B	**28.8800±4.88467**			
NCT	Group A	**13.7600±2.58650**	**1.222**	0.228	significant
	Group B	**12.8800±2.50533**			

Graph No. 5 Intergroup analysis between Group A and Group B comparing difference values of PRE score of FMA and NCT scale with unpaired t test



Interpretation:

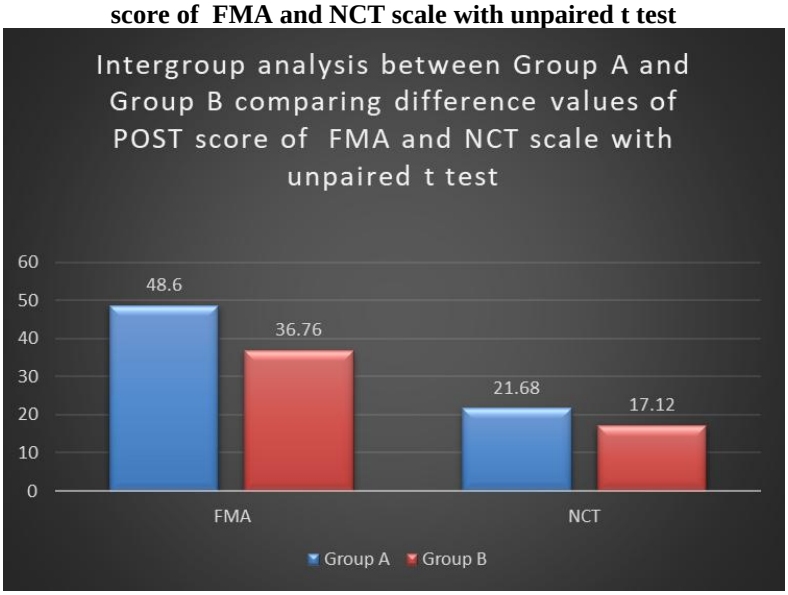
From Table No. 5, Graph No. 5 and Mean and SD values of the intergroup analysis of Pre value of FMA-UE between group A and Group B comes out to be 35.0800 ±5.67832 and 28.8800±4.88467 respectively, with P value of 0.0001 which is less than 0.05 concluding that there is extremely significant difference in outputs of FMA-UE in intergroup analysis.

Also, Mean and SD values of the intergroup analysis of Pre value of NCT between group A and Group B comes out to be 13.7600±2.58650 and 12.8800±2.50533 respectively, with P value of 0.228 which is less than 0.05 considered as significant difference in outputs of NCT in intergroup analysis.

Table No. 1.6 Intergroup analysis between Group A and Group B comparing difference values of POST score of FMA and NCT scale with unpaired t test

	Group	Mean ± SD of difference	Unpaired 't' test value	P- value	Significance
FMA	Group A	**48.6000±6.35085**	7.304	0.0001	extremely significant
	Group B	**36.7600±5.03554**			
NCT	Group A	**21.6800±2.67270**	6.283	0.0001	extremely significant
	Group B	**17.1200±2.45493**			

Graph No. 6 Intergroup analysis between Group A and Group B comparing difference values of POST score of FMA and NCT scale with unpaired t test



Interpretation:

From Table No. 5, Graph No. 5 and Mean and SD values of the intergroup analysis of Post value of FMA-UE between group A and Group B comes out to be 48.6000±6.35085 and 36.7600±5.03554 respectively, with P value of 0.0001 which is less than 0.05 concluding that there is extremely significant difference in outputs of FMA-UE in intergroup analysis.

Also, Mean and SD values of the intergroup analysis of Post value of NCT between group A and Group B comes out to be 21.6800±2.67270 and 17.1200±2.45493 respectively, with P value of 0.0001which is less than 0.05 considered as extremely significant difference in outputs of NCT in intergroup analysis

IV. Discussion

In present study it was proposed that the research investigating the impact of eye-hand coordination devices on improving coordination in stroke survivors with upper limb impairments has produced highly significant outcomes. Individuals who have experienced a stroke frequently suffer from motor function deficits, especially in their upper limbs, which can severely affect their capacity to carry out everyday tasks. The randomized controlled trial's objective was to assess how effective a device aimed at enhancing eye-hand coordination (EHC) is through repetitive, task-oriented training.

The synergistic operation of many sensory-motor systems, such as visual, vestibular system proprioception, and the eye heads and arm control systems, as well as cognitive functions like attention and memory, are all part of normal eye-hand coordination. Hand-Eye Coordination plays a significant part in daily life activities, such as eating, drinking, and writing , Changing pages, etc. Eye-hand coordination is often overlooked in neurologically damaged patients undergoing rehabilitation. The purpose of this study was to determine how an eye-hand coordination device affected the individuals' coordination after a stroke.

The current investigation sought to assess and contrast the results of two neuro-rehabilitation interventions—experimental neuro-rehabilitation (Group A) and conventional neuro-rehabilitation (Group B)—utilizing the Fugl-Meyer Assessment for Upper Extremity (FMA-UE) and the Non-Equilibrium Coordination Test (NCT) as evaluative metrics. These instruments were selected due to their established reliability and sensitivity in identifying variations in motor function and coordination, particularly in individuals undergoing rehabilitation following neurological impairments.

The FMA-UE is a widely recognized instrument utilized for the evaluation of motor function in individuals afflicted with neurological disorders, particularly stroke. It assesses various components such as upper limb mobility, coordination, and muscular strength. The findings derived from this investigation reveal a substantial enhancement in both Group A and Group B. Nevertheless, the advancement observed in Group A was markedly more pronounced. The pre-treatment FMA-UE score for Group A was 35.08 ± 5.68, which escalated to 48.60 ± 6.35 subsequent to treatment, thereby indicating an extraordinarily significant improvement with a p-value of 0.0001. This indicates that the experimental neuro-rehabilitation intervention exerted a profound influence on the motor capabilities of patients, particularly concerning muscular strength, movement regulation, and the overall functionality of the upper limb.

Patients in Group A most likely saw gains in their capacity to carry out daily tasks involving the use of their upper extremities, as shown by the change in their FMA-UE score. Along with increases in muscle strength and the capacity to maintain and modify postures during a variety of activities, these enhancements may also include improved fine motor abilities, such as the ability to grasp things, carry out self-care duties, and coordinate movements. This implies that experimental neuro-rehabilitation may boost motor recovery more effectively than traditional therapy. This could be because experimental therapy uses new techniques or a more specialized approach.

On the other hand, the FMA-UE scores of Group B, who received traditional neuro-rehabilitation, increased from 28.88 ± 4.88 to 36.76 ± 5.04. This improvement was less noticeable than that seen in Group A, although being significant (p-value of 0.0001). This suggests that, even though conventional rehabilitation is beneficial, the extent of motor function recovery may be slower or more constrained when compared to experimental techniques. Although the intervention may not have been as focused or intensive as the experimental strategy in Group A, the gains seen in Group B's FMA-UE may be suggestive of incremental recovery, such as enhanced strength or coordination.

Although they may have made slower progress or seen lesser gains in functional tasks requiring dexterity or fine motor control, patients in Group B may have shown more gradual improvements, such as an increased capacity to grip or move things. The comparatively modest effects could be explained by the fact that some specific brain systems were not as well addressed by traditional approaches as by the experimental therapy.

Coordination, especially non-equilibrium movements, which are essential for tasks requiring fine control, such handwriting or object manipulation, is evaluated by the NCT. Both groups' NCT scale findings demonstrate a notable improvement, with Group A exhibiting a substantial shift. Before therapy, Group A's NCT score was 13.76 ± 2.59; after treatment, it rose to 21.68 ± 2.67. With a p-value of 0.0001, this change was highly

significant and demonstrated a sharp increase in coordination. This suggests that the goal of the experimental neuro-rehabilitation was probably to enhance the patients' capacity for deliberate, controlled movement, which could be demonstrated in everyday activities like reaching for and grabbing objects, keeping balance, and making accurate hand movements.

The alterations seen in Group A indicate that the experimental treatment improved patients' motor coordination, resulting in improved brain-upper limb muscle synchronization. The rise in NCT scores may indicate that patients were more adept and precise in tasks requiring fine adjustments, like picking up small objects or preserving postural stability while engaging in activities. Patients with neurological conditions where coordination problems are widespread, including stroke survivors, may have benefited most from these coordination gains.

Additionally, Group B's NCT scores significantly improved; their pre-treatment score of 12.88 ± 2.51 increased to 17.12 ± 2.45 after treatment, with a p-value of 0.0001. Group B's improvement was statistically significant, although it wasn't quite as significant as Group A's. This shows that whereas traditional neuro-rehabilitation therapy did enhance some aspects of coordination, it was less successful in addressing the finer parts of coordination needed for tasks requiring more accuracy. The relatively smaller increase in the NCT scores suggests that the more complex, high-precision movements were still difficult for the patients in Group B, even though they may have seen moderate improvements in overall movement control, such as an increased ability to perform less complex movements with greater accuracy.

Additionally, the intergroup analysis produced significant results. Group A had a higher baseline score (35.08 ± 5.68), with a p-value of 0.0001, than Group B (28.88 ± 4.88), indicating a highly significant difference in pre-treatment FMA-UE scores between the two groups. This finding suggests that the two groups' initial motor function levels differed, and that Group A's enhancement in upper limb motor control was much more effective as a result of the intervention. This further supported the notion that experimental neuro-rehabilitation was more successful in improving motor function and coordination. The post-treatment comparison also revealed that Group A performed better than Group B in both the FMA-UE and NCT measures.

Patients in Group A most likely saw discernible gains in their functional abilities during the course of treatment. Given the enhanced FMA-UE and

NCT scores, which indicate that their motor function and coordination were much better after treatment, they may have reported feeling more comfortable using their upper limbs for everyday activities like eating, dressing, and doing housework. A key component of neuro-rehabilitation is freedom, and many patients in Group A may have reported feeling more independent or able to carry out tasks more easily.

Even while Group B patients made great strides, it's possible that they reported more gradual and subtle gains. Even though they might not have been as obvious at first, the adjustments they went through might have improved their quality of life. The little gains may not have had as much of an effect on these patients' everyday functional activities as those observed in Group A, even though they may have believed that they could complete simple tasks more quickly.

The results of this study are consistent with other studies in the field of stroke survivors' eye-hand coordination therapy. For example, a research at NYU Langone's Rusk Rehabilitation looked at how stroke patients' eye-hand coordination could be enhanced by technology. The goal of the study was to create functional visual rehabilitation systems that gave patients real-time visuospatial cues while they were reaching for objects1. Similar to the notable gains seen in the current study, this strategy produced increased accuracy and synchronization. ***Rizzo, J. R., et al. (2018).*** [3]

Furthermore, a pilot study conducted at Washington University School of Medicine looked at how gaze and reach biofeedback affected the eye-hand coordination of stroke patients who had had a chronic stroke. The study discovered that extrinsic input on hand and eye motions increased timing and accuracy in completing tasks. This is consistent with the present study's notable improvements in FMA-UE and NCT scores, suggesting that focused therapies can successfully improve motor function and coordination in stroke survivors. ***L. H., et al. (2019)*** [4]

V. Conclusion

The study investigated the impact of eye-hand coordination devices on improving coordination and motor function in upper limb stroke survivors. The randomized controlled trial compared two neuro-rehabilitation interventions: experimental (Group A) and conventional (Group B).

Key Findings:

- **Group A (Experimental):** Showed significant improvements in both Fugl-Meyer Assessment for Upper Extremity (FMA-UE) and Non-Equilibrium Coordination Test (NCT) scores, indicating enhanced motor capabilities and coordination. The pre-treatment FMA-UE score improved from 35.08 ± 5.68 to 48.60 ± 6.35 post-treatment, and the NCT score improved from 13.76 ± 2.59 to 21.68 ± 2.67. These results suggest that the

experimental neuro-rehabilitation intervention was highly effective in improving motor function and coordination.

- **Group B (Conventional):** Also showed significant improvements, but to a lesser extent than Group A. The pre-treatment FMA-UE score improved from 28.88 ± 4.88 to 36.76 ± 5.04 post-treatment, and the NCT score improved from 12.88 ± 2.51 to 17.12 ± 2.45. This indicates that while conventional neuro-rehabilitation is beneficial, the rate and extent of recovery may be slower compared to the experimental approach.

Implications:

- The experimental neuro-rehabilitation approach, which involved eye-hand coordination devices, proved to be more effective in enhancing motor function and coordination than conventional methods.
- Patients in Group A likely experienced significant improvements in their daily activities, reporting increased independence and ease in performing tasks involving their upper limbs.
- The study's findings are consistent with other research in the field, demonstrating the potential of technology-based interventions, such as eye-hand coordination devices, in improving the rehabilitation outcomes for stroke survivors.

Future Research:

- Further studies are needed to optimize the use of eye-hand coordination devices and assess their long-term efficacy.
- Investigating the combination of various technological advancements and personalized rehabilitation protocols could provide deeper insights into improving the quality of life for stroke survivors.

Conflict of interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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