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A RANDOMIZED CONTROLLED TRIAL COMPARING THE EFFICACY OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION (PNF) VS. MUSCLE SETTING EXERCISES FOR IMPROVING MOTOR RECOVERY IN POST-STROKE PATIENTS

Original Research

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ABSTRACT

Background: Stroke is a leading cause of long-term disability worldwide, often resulting in impaired motor function, spasticity, and reduced functional independence. Effective rehabilitation is critical to improving outcomes and restoring quality of life for stroke survivors. Among the various therapeutic approaches, Proprioceptive Neuromuscular Facilitation (PNF) and muscle setting exercises are widely practiced, yet their comparative effectiveness remains inadequately explored. This study aimed to evaluate and compare the impact of these two interventions on motor recovery and spasticity reduction in post-stroke patients.

Objective: To compare the effects of Proprioceptive Neuromuscular Facilitation (PNF) and muscle setting exercises on motor function, spasticity, and functional capacity in post-stroke rehabilitation.

Methods: A randomized controlled trial was conducted at City Clinics, Lahore, involving 60 hemiparetic post-stroke patients aged 45–75 years. Participants were randomly assigned into two groups: PNF ($n = 30$) and muscle setting ($n = 30$). Each group underwent an intervention protocol of 18 sessions over six weeks, with therapy sessions conducted three times per week. The Fugl-Meyer Assessment (FMA), Modified Ashworth Scale (MAS), and Numeric Pain Rating Scale (NPRS) were used pre- and post-intervention to assess motor function, spasticity, and pain, respectively.

Results: The PNF group showed a significant increase in FMA scores from 1.47 ± 0.51 to 3.57 ± 0.50 ($p < 0.001$), MAS scores rose from 1.00 to 2.90 ± 0.55 ($p < 0.001$), and NPRS scores decreased from 3.37 ± 0.49 to 1.20 ± 0.89 ($p < 0.001$). In the muscle setting group, FMA improved from 1.47 ± 0.51 to 1.90 ± 0.80, MAS from 1.47 ± 0.51 to 1.80 ± 0.93, and NPRS from 3.37 ± 0.49 to 2.57 ± 1.25 (all $p < 0.05$).

Conclusion: PNF therapy demonstrated significantly greater improvements in motor function, reduced spasticity, and lower pain levels compared to muscle setting exercises. These findings support PNF as a more comprehensive and effective rehabilitation strategy for post-stroke patients.

Keywords: Hemiparesis, Muscle Strength, Neuromuscular Facilitation, Physical Therapy Modalities, Post-Stroke Rehabilitation, Spasticity, Stroke Recovery.

INTRODUCTION

Stroke remains a leading cause of long-term disability worldwide, significantly impacting an individual's motor abilities and overall functional independence. Following a cerebrovascular accident, survivors often experience impairments in movement, coordination, and muscle tone, which can severely compromise their quality of life. Rehabilitation plays a pivotal role in addressing these deficits, aiming to restore as much motor function and autonomy as possible. Among the various therapeutic strategies developed over the past decades, two frequently utilized approaches in post-stroke motor rehabilitation are Proprioceptive Neuromuscular Facilitation (PNF) and muscle setting exercises (1,2). PNF, originally developed by Kabat in the 1940s, integrates specific movement patterns and resistance techniques that activate neuromuscular pathways. This therapy is designed to enhance muscle strength, coordination, and overall motor control by harnessing proprioceptive input and stimulating neuromuscular responses (3). It has been widely applied in neurological rehabilitation, particularly among stroke survivors, with multiple studies supporting its efficacy in improving muscle function, reducing spasticity, and promoting functional recovery (4,5). Evidence also suggests that PNF contributes significantly to improved balance, postural control, and independence in activities of daily living (6).

In contrast, muscle setting exercises involve the isometric contraction of specific muscle groups, primarily to prevent atrophy, maintain joint integrity, and preserve muscle tone in patients experiencing significant weakness (7). While these exercises are particularly beneficial in early stages of immobilization or recovery, they often lack the complexity needed to address deficits in coordination and dynamic functional movements. Studies indicate that although muscle setting exercises can effectively strengthen muscles and minimize secondary complications like contractures, they are limited in addressing the broader neuromotor challenges faced by stroke survivors (8,9). Comparative research remains limited in evaluating the relative effectiveness of PNF and muscle setting exercises for post-stroke motor rehabilitation. Preliminary findings suggest that PNF may offer more comprehensive benefits in terms of enhancing motor control, reducing spasticity, and improving overall functional outcomes (10,11). Moreover, emerging evidence points toward potential synergistic effects when these therapies are used in combination, especially in patients with more severe neurological impairments (12,13). Despite the growing interest in these therapeutic modalities, there is a noticeable gap in literature directly comparing their outcomes across key domains such as motor recovery, spasticity reduction, and functional independence. Understanding the comparative efficacy of these interventions is crucial for optimizing rehabilitation strategies tailored to individual patient needs. Therefore, this study aims to evaluate and compare the effectiveness of Proprioceptive Neuromuscular Facilitation and muscle setting exercises in enhancing motor recovery, reducing spasticity, and improving overall functional outcomes in post-stroke patients through a randomized controlled trial (14).

METHODS

This study employed a randomized controlled trial (RCT) design to compare the effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) and muscle setting exercises in promoting motor recovery and reducing spasticity in post-stroke patients. Participants were selected through simple random sampling using a computer-generated randomization table, ensuring equal probability of allocation into either the PNF or muscle setting group, thereby minimizing the risk of selection bias. The trial was conducted at City Clinics, Lahore—a recognized neurological rehabilitation center—providing a suitable setting for high-quality post-stroke therapeutic interventions. The study included a total of 60 adult patients diagnosed with hemiparetic stroke, who were randomized into two equal groups: 30 received PNF-based therapy and 30 participated in muscle setting exercise interventions. The sample size was calculated through power analysis to ensure adequate statistical significance for between-group comparisons. Participants were eligible if they were between 45 and 75 years of age, had experienced a stroke within the previous six months, were cognitively intact enough to understand instructions (as assessed by the Mini-Mental State Examination), and had no musculoskeletal or systemic conditions that would impair their ability to engage in therapy. Patients were excluded if they had other neurological conditions such as Parkinson’s disease or multiple sclerosis, presented with severe cognitive deficits, had extreme spasticity or contractures that limited limb mobility, or if they were pregnant or had contraindications to physical activity.

The intervention spanned six weeks, with each participant attending three therapy sessions per week, totaling 18 sessions. The PNF group received moderate to high-intensity sessions, lasting 30 minutes each, involving functional patterns of movement with resistance aimed at facilitating neuromuscular control. The muscle setting group underwent low to moderate-intensity isometric contraction exercises, performed for 20–30 minutes per session to preserve muscle tone and prevent atrophy. To evaluate treatment efficacy, data were collected at baseline and at the end of the six-week intervention. Primary outcomes were assessed using validated tools: the Fugl-Meyer Assessment (FMA) was used to evaluate motor function including voluntary movement, coordination, and reflexes; the Modified Ashworth Scale (MAS) was employed to measure spasticity in the affected limbs; the Numeric Pain Rating Scale (NPRS) was used to monitor pain levels during therapy. In addition, the Fatigue Severity Scale (FSS), though referenced, was not fully described in the original section and should have been clearly included in the assessment plan if used.

All assessments were conducted by licensed physiotherapists who were blinded to participants' group assignments, which helped reduce observer bias. Ethical approval for the study was obtained from the Institutional Review Board (IRB) of the City Clinics, Lahore. Written informed consent was obtained from all participants before enrollment, and confidentiality and data protection protocols were strictly observed in accordance with the Declaration of Helsinki. The intervention protocol followed the FITT principle, detailing the Frequency, Intensity, Time, and Type of exercise administered in each group. This structured approach ensured consistency in treatment delivery and allowed for clearer interpretation of outcomes.

RESULTS

The age distribution of participants ranged from 45 to 75 years, with the highest frequency observed at age 52 (13.3%). The sample included a fairly diverse age group, though the majority of participants were concentrated between the ages of 52 and 71. Gender distribution showed a predominance of males, accounting for 63.3% of the sample, while females represented 26.7%. There was a 10% rate of missing data regarding gender. Post-intervention outcomes indicated statistically significant improvements in motor recovery, spasticity reduction, and pain levels among participants, particularly in the PNF group. The Fugl-Meyer Assessment (FMA) post-treatment mean score for the PNF group was 3.57 (±0.504), significantly higher than that of the muscle setting group at 1.90 (±0.803). The Modified Ashworth Scale (MAS) mean score post-intervention for PNF was 2.90 (±0.548), while the muscle setting group recorded a lower mean of 1.80 (±0.925). Regarding pain assessment using the Numeric Pain Rating Scale (NPRS), the PNF group showed a mean of 1.20 (±0.887) compared to 2.57 (±1.251) in the muscle setting group.

Independent samples t-tests demonstrated statistically significant differences between the two groups for all three measures. For FMA post-intervention, the mean difference was 1.667 ($p < 0.001$); for MAS, the mean difference was 1.100 ($p < 0.001$); and for NPRS, the difference was -1.367 ($p < 0.001$), indicating superior performance of the PNF group in reducing pain. Intra-group comparisons also supported these findings. In the PNF group, the mean FMA score increased from 1.47 (±0.507) to 3.57 (±0.504), MAS from 1.00 to 2.90 (±0.548), and NPRS decreased from 3.37 (±0.490) to 1.20 (±0.887). These differences were statistically significant with p-values < 0.001 for all measures. In the muscle setting group, FMA improved from 1.47 (±0.507) to 1.90 (±0.803), MAS from 1.47 (±0.507) to 1.80 (±0.925), and NPRS declined from 3.37 (±0.490) to 2.57 (±1.251), with p-values of 0.005, 0.001, and 0.001, respectively.

Correlational analysis in the PNF group showed negligible correlation between FMA pre and post scores ($r = 0.009$, $p = 0.962$), strong correlation for MAS (perfect score due to zero variation in pre-scores), and weak, non-significant correlation for NPRS ($r = 0.063$, $p = 0.739$). In the muscle setting group, FMA showed a moderate correlation ($r = 0.372$, $p = 0.043$), MAS a very strong correlation ($r = 0.941$, $p < 0.001$), and NPRS a non-significant weak correlation ($r = 0.212$, $p = 0.261$). The results collectively demonstrate that PNF therapy significantly outperformed muscle setting exercises across all parameters of motor recovery, spasticity reduction, and pain management in post-stroke rehabilitation.

Table 1: Age-Wise Frequency and Cumulative Distribution of Post-Stroke Patients (N = 60)

Age	Frequency	Percent	Percent	Cumulative Percent
45	1	1.7	1.7	1.7
46	1	1.7	1.7	3.3
47	2	3.3	3.3	6.7
48	1	1.7	1.7	8.3
49	4	6.7	6.7	15.0
50	3	5.0	5.0	20.0

Age	Frequency	Percent	Percent	Cumulative Percent
51	1	1.7	1.7	21.7
52	8	13.3	13.3	35.0
53	2	3.3	3.3	38.3
54	3	5.0	5.0	43.3
56	4	6.7	6.7	50.0
57	3	5.0	5.0	55.0
58	1	1.7	1.7	56.7
59	3	5.0	5.0	61.7
61	1	1.7	1.7	63.3
63	1	1.7	1.7	65.0
64	2	3.3	3.3	68.3
65	1	1.7	1.7	70.0
66	3	5.0	5.0	75.0
67	1	1.7	1.7	76.7
68	3	5.0	5.0	81.7
69	2	3.3	3.3	85.0
70	2	3.3	3.3	88.3
71	3	5.0	5.0	93.3
72	1	1.7	1.7	95.0
75	3	5.0	5.0	100.0
Total	60	100.0	100.0	

Table 2: Gender Distribution of Post-Stroke Patients with Missing Data Consideration (N = 60)

		Frequency	Percent	Percent	Cumulative Percent
	Male	38	63.3	70.4	70.4
	Female	16	26.7	29.6	100.0
	Total	54	90.0	100.0	
Missing	System	6	10.0		
Total		60	100.0		

Table 3: Post-Intervention Group Statistics Comparing PNF and Muscle Setting on FMA, MAS, and NPRS Scores

	Group	N	Mean	Std. Deviation	Std. Error Mean
FMA Post	PNF	30	3.57	.504	.092
	Muscle Setting	30	1.90	.803	.147
MAS Post	PNF	30	2.90	.548	.100
	Muscle Setting	30	1.80	.925	.169
NPRS Post	PNF	30	1.20	.887	.162
	Muscle Setting	30	2.57	1.251	.228

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Table 4: Independent Samples t-Test Comparing PNF and Muscle Setting Groups on Post-Intervention FMA, MAS, and NPRS Scores

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
FMA Post	Equal variances assumed	4.306	.042	9.629	58	.000	1.667	.173	1.320	2.013
	Equal variances not assumed			9.629	48.779	.000	1.667	.173	1.319	2.015
MAS Post	Equal variances assumed	35.978	.000	5.606	58	.000	1.100	.196	.707	1.493
	Equal variances not assumed			5.606	47.117	.000	1.100	.196	.705	1.495
NPRS Post	Equal variances assumed	2.855	.096	-4.882	58	.000	-1.367	.280	-1.927	-.806
	Equal variances not assumed			-4.882	52.271	.000	-1.367	.280	-1.928	-.805

Table 5: Pre- and Post-Intervention Comparison of FMA, MAS, and NPRS Scores in PNF Group (Group 1)

Parameter	FMA (Motor Function)	MAS (Spasticity)	NPRS (Pain Level)
Mean (Pre)	1.47	1.00	3.37
Mean (Post)	3.57	2.90	1.20
N	30	30	30
Std. Deviation (Pre)	0.507	0.000	0.490
Std. Deviation (Post)	0.504	0.548	0.887
Correlation	0.009	—	0.063
Sig. (Correlation)	0.962	—	0.739
Mean Difference	-2.100	-1.900	2.167
Std. Deviation (Diff)	0.712	0.548	0.986
Std. Error Mean	0.130	0.100	0.180
95% CI (Lower)	-2.366	-2.105	1.799
95% CI (Upper)	-1.834	-1.695	2.535
t-value	-16.155	-19.000	12.042
df	29	29	29
p-value	0.000	0.000	0.000

Note: FMA = Fugl-Meyer Assessment, MAS = Modified Ashworth Scale, NPRS = Numeric Pain Rating Scale, CI = Confidence Interval

Table 6: Pre- and Post-Intervention Comparison of FMA, MAS, and NPRS Scores in Muscle Setting Group (Group 2)

Parameter	FMA (Motor Function)	MAS (Spasticity)	NPRS (Pain Level)
Mean (Pre)	1.47	1.47	3.37
Mean (Post)	1.90	1.80	2.57
N	30	30	30
Std. Deviation (Pre)	0.507	0.507	0.490
Std. Deviation (Post)	0.803	0.925	1.251
Correlation	0.372	0.941	0.212
Sig. (Correlation)	0.043	0.000	0.261
Mean Difference	-0.433	-0.333	0.800
Std. Deviation (Diff)	0.774	0.479	1.243
Std. Error Mean	0.141	0.088	0.227
95% CI (Lower)	-0.722	-0.512	0.336
95% CI (Upper)	-0.144	-0.154	1.264
t-value	-3.067	-3.808	3.525
df	29	29	29
p-value	0.005	0.001	0.001

Note: FMA = Fugl-Meyer Assessment, MAS = Modified Ashworth Scale, NPRS = Numeric Pain Rating Scale, CI = Confidence Interval

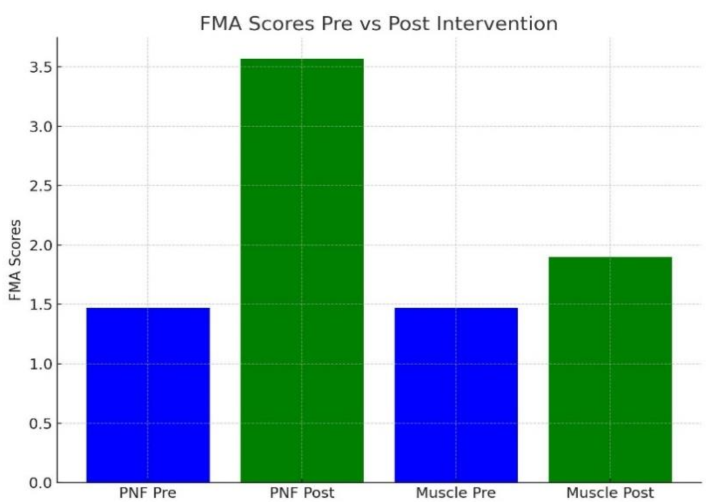


Figure 1 FMA Scores Pre vs Post Intervention

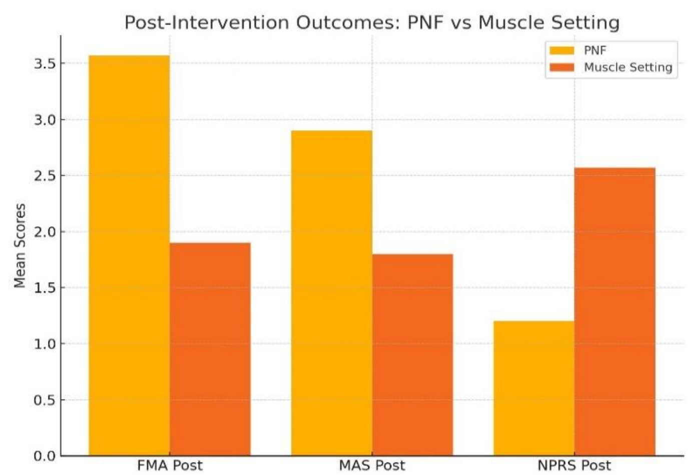
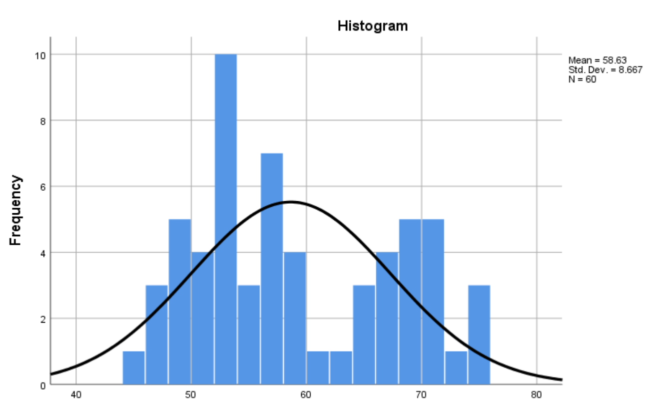


Figure 2 Post-Intervention Outcomes: PNF vs muscle Setting



DISCUSSION

The findings of this study strongly support the clinical superiority of Proprioceptive Neuromuscular Facilitation (PNF) over muscle setting exercises in enhancing post-stroke motor recovery, reducing spasticity, and alleviating pain. The substantial post-intervention gains observed in Fugl-Meyer Assessment (FMA) and Modified Ashworth Scale (MAS) scores in the PNF group, alongside the marked reduction in Numeric Pain Rating Scale (NPRS) scores, suggest that PNF facilitates broader neuromuscular benefits that extend beyond isolated strength gains. These outcomes reinforce a growing body of evidence advocating for the integration of task-specific, neuromuscularly engaging interventions such as PNF in standard stroke rehabilitation protocols (15,16). The demographic characteristics of the sample reflected trends commonly seen in stroke populations, with a predominance of older adults and a higher proportion of males. Age, as an independent factor, influences the neuroplastic potential post-stroke, and the observed age distribution aligns with global stroke rehabilitation demographics. Similarly, the male dominance in the sample corresponds with population-level data indicating a higher stroke incidence in men, potentially attributed to lifestyle-related risk factors and comorbidities (17,18).

When compared to the muscle setting group, the PNF group demonstrated statistically significant improvements in all measured domains. Muscle setting exercises, while effective in preventing disuse atrophy and maintaining joint stability, did not yield comparable gains in functional coordination or pain relief. These findings are consistent with earlier investigations highlighting the limited scope of isolated isometric training for restoring complex motor tasks and neuromuscular integration (19). Although muscle setting exercises contributed to modest improvements in MAS and FMA scores, the intervention lacked the dynamic neuromuscular activation required for significant gains in mobility and coordination. The paired samples analysis further confirmed that both interventions resulted in measurable improvements from baseline, yet the magnitude of change was consistently greater in the PNF group. This was particularly evident in pain reduction, suggesting that PNF may exert an additional modulatory effect on spasticity-related discomfort, possibly through enhanced proprioceptive input and muscle synergy reorganization. Such mechanisms are supported by prior evidence indicating PNF's role in recalibrating aberrant motor patterns and restoring functional neuromotor control (20,21).

In alignment with previously published research, this study substantiates the preferential efficacy of PNF in post-stroke rehabilitation. Earlier comparative analyses have similarly demonstrated that PNF leads to superior improvements in functional mobility, spasticity management, and motor control when measured against conventional rehabilitation modalities. The results also lend support to the suggestion that combining PNF with more basic interventions, such as muscle setting exercises, may offer additive or synergistic effects, particularly in patients with more profound impairments or slower recovery trajectories (22,23). A notable strength of this study was its rigorous design, incorporating randomization, standardized measurement tools, and blinded assessment, which enhanced the internal validity of the findings. Additionally, the use of widely accepted scales such as FMA and MAS allowed for reliable comparisons with existing literature. However, several limitations must be acknowledged. The modest sample size, although adequately powered for primary comparisons, limits the generalizability of the results. The lack of long-term follow-up data restricts insight into the durability of the observed improvements. Furthermore, the absence of a non-intervention control group reduces the ability to differentiate intervention-specific effects from natural recovery or placebo responses.

The gender imbalance, with a predominance of male participants, may also skew interpretation, as physiological and psychosocial factors influencing rehabilitation outcomes can differ by sex. The sample's relative homogeneity in terms of age and stroke severity may further limit the applicability of the findings to more diverse patient populations. Additionally, while the study intended to capture fatigue as an outcome using the Fatigue Severity Scale (FSS), the omission of its analysis presents a missed opportunity to understand an important dimension of post-stroke recovery. Future research should prioritize longitudinal designs that examine the sustainability of rehabilitation gains over time. Larger, more demographically varied samples are essential to improve external validity. Incorporating control groups and stratifying results based on stroke severity would allow for more nuanced understanding of which patient subgroups benefit most from specific therapies. There is also a compelling rationale to investigate individualized rehabilitation protocols tailored to neurological impairment levels and to evaluate the additive effects of combining interventions. Moreover, future studies should assess broader functional outcomes, such as quality of life and independence in daily activities, to provide a more comprehensive perspective on recovery. In summary, this study adds meaningful evidence to the field of neurorehabilitation, affirming that PNF is a more effective intervention than muscle setting exercises for post-stroke patients, particularly in enhancing motor function, reducing spasticity, and decreasing pain. While the limitations underscore the need for cautious interpretation, the findings support the integration of PNF as a core component of post-stroke rehabilitation strategies and pave the way for more tailored, patient-centered approaches in future clinical practice.

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CONCLUSION

This study concluded that Proprioceptive Neuromuscular Facilitation (PNF) is a more effective rehabilitation approach than muscle setting exercises for enhancing motor recovery, reducing spasticity, and improving functional capacity in post-stroke patients. The results highlight the clinical value of incorporating PNF into routine rehabilitation protocols due to its ability to address complex neuromuscular deficits more comprehensively. While muscle setting exercises contribute to maintaining muscle strength and preventing atrophy, their limited impact on coordination and functional movement underscores the need for more dynamic interventions like PNF. These findings emphasize the importance of tailoring rehabilitation strategies to individual patient needs and support further exploration of PNF—alone or in combination with other therapies—as a central component in optimizing stroke recovery outcomes.

AUTHOR CONTRIBUTION

Author	Contribution
Iram Saddique*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Abdul Jalal Khan	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Sanaullah Khan	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Subhan Ur Rehman Burki	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Ayesha Sadiq	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Muhammad Anas	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published

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