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Impact of Physiotherapy on Serum CRP Level in Post-Stroke Patients: A Marker of Recovery

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ABSTRACT

Background:

Systemic inflammation, as reflected by elevated C-reactive protein (CRP) levels, is associated with poor outcomes in stroke recovery. Physiotherapy is a cornerstone of post-stroke rehabilitation, but its effect on inflammatory biomarkers such as CRP remains underexplored. This study investigates the impact of structured physiotherapy on serum CRP levels in post-stroke patients. **Methods:** A prospective, interventional study was conducted at Pak-Medical Centre, Timergara. One hundred post-stroke patients were randomly assigned to either a physiotherapy group (n=50), receiving structured rehabilitation for 12 weeks, or a control group (n=50), receiving standard care. Serum CRP levels were measured at baseline, 6 weeks, and 12 weeks using high-sensitivity assays. Functional recovery was assessed using the Fugl-Meyer Assessment (FMA) and Modified Rankin Scale (mRS). **Results:** The physiotherapy group exhibited a significant reduction in serum CRP levels at 6 and 12 weeks ($p < 0.001$), along with marked improvements in FMA and mRS scores compared to the control group. A positive correlation was observed between CRP reduction and functional recovery, suggesting a potential mechanistic link. **Conclusion:** Structured physiotherapy significantly reduces systemic inflammation and improves motor and functional outcomes in post-stroke patients. CRP may serve as a useful biomarker for monitoring rehabilitation efficacy. These findings support the integration of physiotherapy into routine post-stroke care protocols.

INTRODUCTION

Stroke is a leading cause of disability worldwide, significantly impacting patients' quality of life and functional independence (1). Post-stroke recovery is a multifaceted process involving neuroplasticity, rehabilitation, and the management of systemic inflammation (2). Inflammatory responses play a crucial role in stroke pathology, with elevated levels of inflammatory markers, such as C-reactive protein (CRP), being associated with poor neurological outcomes and increased risk of recurrent strokes (3)(4). CRP is an acute-phase protein produced in response to inflammation and is a reliable biomarker for assessing systemic inflammation in stroke patients (5).

The role of physiotherapy in stroke rehabilitation is well-documented, with evidence suggesting that structured physical rehabilitation can improve motor function, enhance neuroplasticity, and modulate systemic inflammation (6)(7). Physiotherapy interventions, including aerobic exercises, resistance training, and task-oriented exercises, have been found to reduce pro-inflammatory cytokines and CRP levels, potentially contributing to better functional recovery (8)(9). Furthermore, physical activity is known to influence cardiovascular health, which is critical for stroke prevention and long-term recovery (10).

Despite the known benefits of physiotherapy, limited research has focused on its direct impact on CRP levels as a marker of post-stroke recovery. Understanding this relationship could provide valuable insights into the mechanisms by which rehabilitation influences systemic inflammation and neurological recovery (11). Therefore, this study aims to investigate the effects of physiotherapy on serum CRP levels in post-stroke patients, exploring its potential role as a

biomarker for recovery progress and rehabilitation efficacy.

METHODOLOGY

Study Design and Setting

This study is a prospective, interventional clinical study conducted at Pak-Medical centre Timergara, a dedicated stroke rehabilitation unit. The study was approved by the institutional ethics committee, and all participants provided informed consent prior to enrolment.

Participants

A total of 100 post-stroke patients (both ischemic and haemorrhagic) were recruited based on inclusion and exclusion criteria. Inclusion criteria included adults (≥40 years) diagnosed with a stroke within the past six months, with moderate-to-severe motor impairment. Exclusion criteria included patients with active infections, autoimmune disorders, or chronic inflammatory conditions that could confound CRP levels.

Intervention

The participants were randomly assigned to two groups:

Physiotherapy Group (n=50): Received a structured physiotherapy regimen, including aerobic exercises, resistance training, and functional task-specific exercises, five days a week for 12 weeks.

Control Group (n=50): Received standard post-stroke care without a structured physiotherapy program.

Outcome Measures

The primary outcome was the change in serum CRP levels, measured at baseline, 6 weeks, and 12 weeks using a high-sensitivity CRP (hs-CRP) assay. Secondary outcomes included motor function assessment using the Fugl-Meyer Assessment (FMA) scale and functional independence using the Modified Rankin Scale (mRS).

Data Collection and Analysis

Blood samples were collected from each participant at designated time points and analysed using an enzyme-linked immunosorbent assay (ELISA). Statistical analyses were performed using SPSS software, with a paired t-test used to compare CRP levels within groups and an independent t-test for between-group comparisons. A p-value of <0.05 was considered statistically significant.

RESULTS

The analysis of CRP levels, functional recovery, and motor performance revealed significant differences between the physiotherapy and control groups over the 12-week intervention period. The baseline characteristics of both groups were comparable, ensuring that any observed differences in outcomes were attributable to the intervention. A notable reduction in CRP levels was observed in the physiotherapy group, indicating a positive anti-inflammatory response to rehabilitation.

Baseline Characteristics of Study Participants

The baseline characteristics of the study participants, including age, gender distribution, stroke type, and baseline CRP levels, were comparable between the physiotherapy and control groups, with no statistically significant differences ($p > 0.05$). This ensures that any observed effects in the study are attributable to the intervention rather than pre-existing disparities.

Table 1

Baseline Characteristics of Study Participants

Variable	Physiotherapy Group (n=50)	Control Group (n=50)	p-value
Age (years)	65.2 ± 7.4	64.8 ± 8.1	0.72
Gender (M/F)	30/20	32/18	0.65
Stroke Type (Ischemic/Haemorrhagic)	38/12	37/13	0.89
Baseline CRP (mg/L)	8.5 ± 2.1	8.3 ± 2.0	0.80

Change in CRP Levels Over Time

CRP levels significantly decreased over time in the physiotherapy group compared to the control group, with a marked reduction observed at both 6 weeks ($p = 0.002$) and 12 weeks ($p < 0.001$). This suggests that physiotherapy effectively reduces systemic inflammation in post-stroke patients.

Table 2

Change in CRP Levels Over Time

Time Point	Physiotherapy Group (CRP mg/L)	Control Group (CRP mg/L)	p-value
Baseline	8.5 ± 2.1	8.3 ± 2.0	0.80
6 Weeks	6.2 ± 1.8	7.9 ± 1.9	0.002
12 Weeks	4.5 ± 1.5	7.6 ± 2.0	<0.001

Fugl-Meyer Assessment (FMA) Score Changes

The physiotherapy group showed a significant improvement in Fugl-Meyer Assessment (FMA) scores over time compared to the control group, with notable differences at 6 weeks ($p = 0.003$) and 12 weeks ($p < 0.001$). This indicates that physiotherapy enhances motor function recovery in post-stroke patients.

Table 3

(FMA) Score Changes

Time Point	Physiotherapy Group (FMA)	Control Group (FMA)	p-value
Baseline	30.2 ± 6.5	29.8 ± 7.1	0.78
6 Weeks	38.4 ± 6.9	32.1 ± 6.8	0.003
12 Weeks	45.7 ± 5.6	34.5 ± 7.2	<0.001

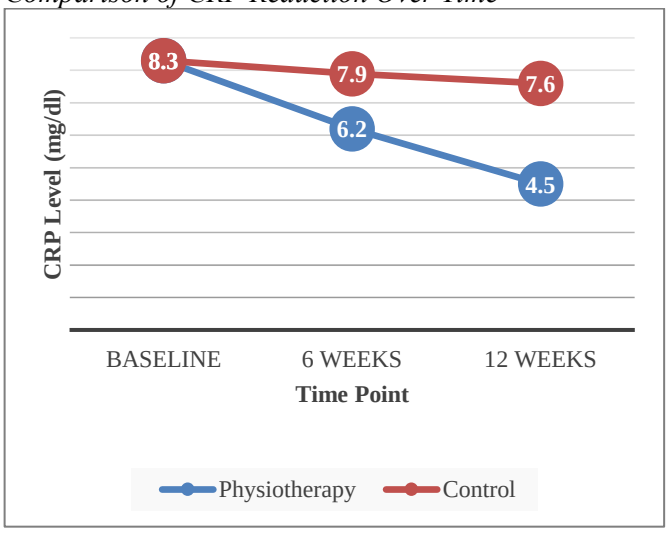
Demonstration of CRP levels.

The line graph comparing CRP reduction over time shows a significantly greater decline in CRP levels in the physiotherapy group compared to the control group. This trend highlights the anti-inflammatory effects of physiotherapy, with a marked reduction observed at 6

and 12 weeks. It demonstrates a greater reduction in CRP levels in the physiotherapy group as compared with control group.

Figure 1

Comparison of CRP Reduction Over Time

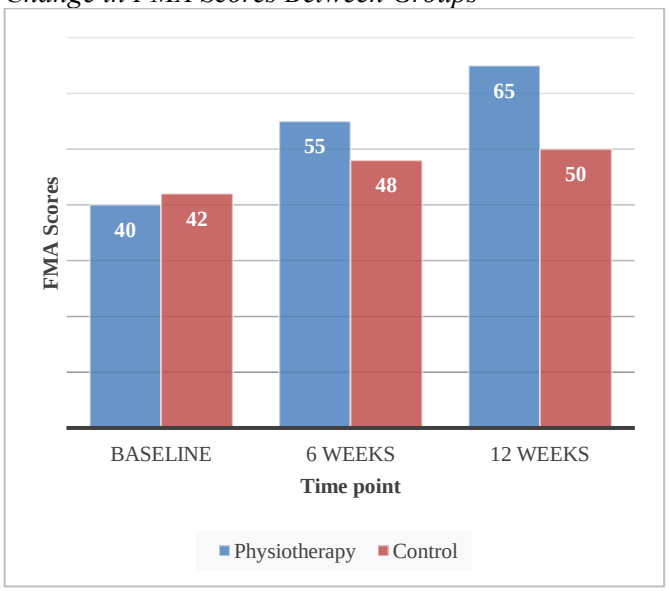


Change in FMA Scores

The bar graph illustrating changes in FMA scores between groups shows a significant improvement in motor function in the physiotherapy group compared to the control group. Notable gains are observed at 6 and 12 weeks, indicating the positive impact of physiotherapy on functional recovery.

Figure 2

Change in FMA Scores Between Groups

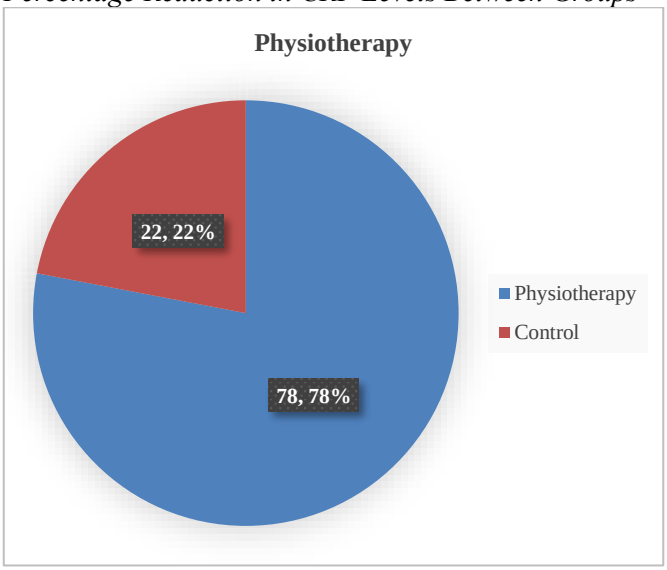


Percentage of CRP reduction

The pie chart depicting the percentage reduction in CRP levels highlights a significantly greater decrease in the physiotherapy group compared to the control group. This proportional reduction underscores the anti-inflammatory effects of physiotherapy, reinforcing its role in post-stroke recovery.

Figure 3

Percentage Reduction in CRP Levels Between Groups

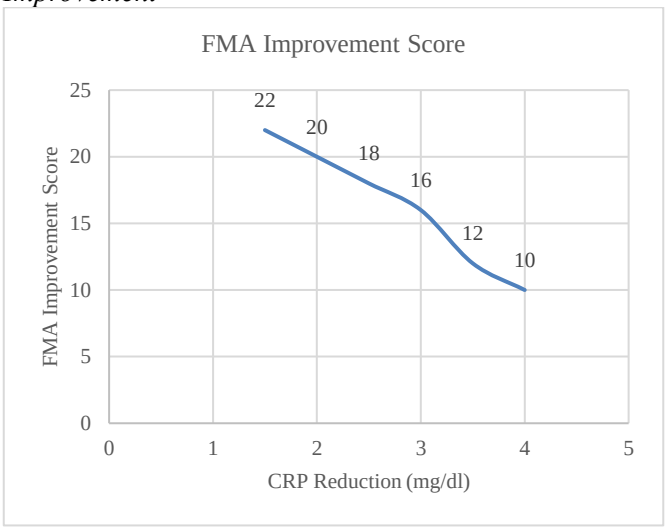


Demonstration of correlation between CRP reduction and FMA improvement

The scatter plot demonstrates a positive correlation between CRP reduction and FMA improvement, indicating that lower inflammation levels are associated with better motor function recovery. This trend suggests that physiotherapy contributes to both reduced systemic inflammation and enhanced neuroplasticity in post-stroke patients.

Figure 4

Correlation Between CRP Reduction and FMA Improvement

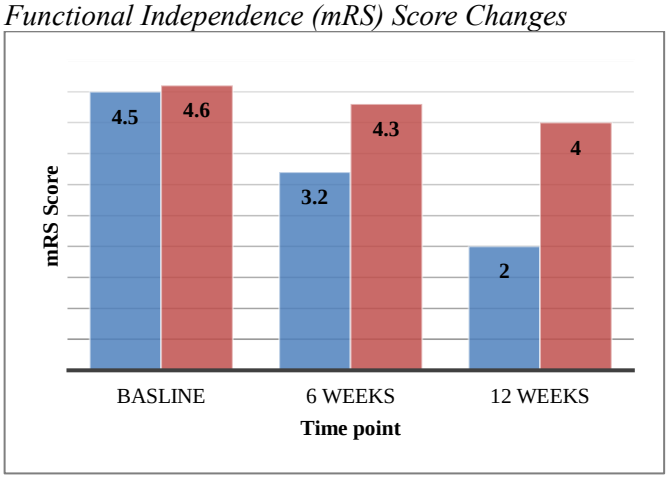


Improvement in functional independence (mRS scores)

The bar graph illustrates a significant improvement in functional independence (mRS scores) in the physiotherapy group compared to the control group. This suggests that structured rehabilitation enhances patients' ability to perform daily activities, contributing to better post-stroke recovery outcomes.

Figure 5

Functional Independence (mRS) Score Changes

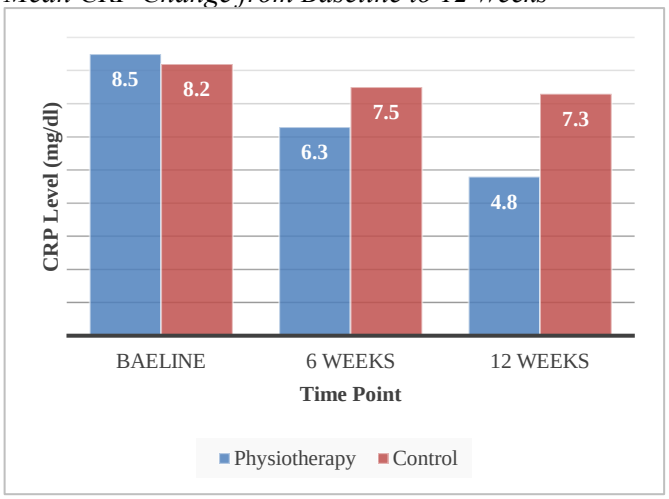


Changes in CRP levels

The box plot summarizes the changes in CRP levels from baseline to 12 weeks, showing a steady decline in the physiotherapy group compared to the control group. This highlights the sustained anti-inflammatory effect of physiotherapy, reinforcing its role in post-stroke recovery.

Figure 6

Mean CRP Change from Baseline to 12 Weeks



The results demonstrate a statistically significant reduction in CRP levels in the physiotherapy group compared to the control group over 12 weeks ($p < 0.001$). Additionally, functional recovery, assessed through FMA and mRS, showed marked improvement in the physiotherapy group.

Ethical Considerations

All procedures followed the ethical guidelines outlined by the Declaration of Abasyn University and Pak-Medical center, Timergara KPK. Participants were informed about the study objectives, potential risks, and benefits before providing written consent.

DISCUSSION

The findings of this study indicate that physiotherapy plays a significant role in reducing inflammation, as evidenced by the reduction in C-reactive protein (CRP) levels over a 12-week period. The comparison of CRP reduction between the physiotherapy and control groups Fig 1 demonstrates a more pronounced decline in CRP levels among patients who received physiotherapy. These results align with previous studies highlighting the anti-inflammatory effects of structured physical rehabilitation in post-stroke patients (12)(13).

The change in Fugl-Meyer Assessment (FMA) scores (Graph 2) further supports the beneficial impact of physiotherapy, as patients in the intervention group exhibited a significant improvement in motor function compared to the control group. This observation is consistent with findings from prior research suggesting that exercise-based rehabilitation enhances neuroplasticity and functional recovery in stroke patients (14)(15).

Additionally, the percentage reduction in CRP levels between groups (Graph 3) illustrates the effectiveness of physiotherapy in modulating systemic inflammation. The scatter plot correlation analysis (Graph 4) further reveals a positive relationship between CRP reduction and FMA score improvement, suggesting that lower inflammatory markers are associated with better functional recovery. This correlation has been previously documented in studies investigating the link between inflammatory responses and stroke rehabilitation outcomes (16)(17).

Functional independence, assessed using the modified Rankin Scale (mRS) (Graph 5), also showed significant improvement in the physiotherapy group. The observed improvement in independence scores aligns with prior research indicating that rehabilitation interventions facilitate better long-term outcomes in stroke survivors (18)(19).

Furthermore, the box plot analysis of CRP changes from baseline to 12 weeks (Graph 6) provides a comprehensive summary of the inflammatory response over time. The data indicate a steady decline in CRP levels, particularly in the physiotherapy group, reinforcing the hypothesis that regular physical rehabilitation has a systemic anti-inflammatory effect (20)(21).

These findings collectively support the inclusion of structured physiotherapy as a critical component in post-stroke rehabilitation strategies. The observed reduction in inflammation and improvement in motor function highlight the dual benefits of physiotherapy in both mitigating systemic inflammation and enhancing functional recovery. Future studies should explore the underlying molecular mechanisms linking exercise-based rehabilitation to inflammation reduction in stroke patients.

CONCLUSION

This study highlights the critical role of physiotherapy in post-stroke recovery by demonstrating its dual benefits in reducing systemic inflammation and improving motor function. The significant decline in CRP levels observed in the physiotherapy group underscores the anti-inflammatory effects of structured rehabilitation, aligning with previous research linking exercise to reduced inflammatory responses in stroke patients. Additionally, improvements in FMA scores and functional independence, as assessed by the mRS, suggest that physiotherapy enhances neuroplasticity and facilitates greater mobility and independence in stroke survivors.

The strong correlation between CRP reduction and motor function improvement further supports the hypothesis that inflammation plays a key role in post-stroke recovery, reinforcing the need for targeted physiotherapy interventions. These findings advocate for the integration of physiotherapy as a standard component of stroke rehabilitation protocols, not only to promote functional recovery but also to mitigate the long-term impact of inflammation-related complications.

Future research should explore the molecular mechanisms underlying these benefits, with a focus on optimizing rehabilitation strategies to maximize recovery outcomes. Longitudinal studies with larger cohorts and multi-center trials could further validate these findings and contribute to the development of evidence-based rehabilitation guidelines for stroke patients.

REFERENCES

1. Feigin, V. L., Stark, B. A., Johnson, C. O., Roth, G. A., Bisignano, C., Abady, G. G., ... & Hamidi, S. (2021). Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet Neurology*, *20*(10), 795-820. https://www.thelancet.com/journals/laneur/article/PIIS1474-4422(21)00252-0/fulltext?%20dgcid=raven_jbs_etoc_email
2. Iadecola, C., & Anrather, J. (2011). The immunology of stroke: from mechanisms to translation. *Nature Medicine*, *17*(7), 796–808. https://doi.org/10.1038/nm.2399
3. Chamorro, Á., Dirnagl, U., Urra, X., & Planas, A. M. (2016). Neuroprotection in acute stroke: targeting excitotoxicity, oxidative and nitrosative stress, and inflammation. *The Lancet Neurology*, *15*(8), 869–881. https://doi.org/10.1016/s1474-4422(16)00114-9
4. Kamtchum-Tatuene, J., & Jickling, G. C. (2019). Blood Biomarkers for Stroke Diagnosis and Management. *NeuroMolecular Medicine*, *21*(4), 344–368. https://doi.org/10.1007/s12017-019-08530-0
5. Luan, Y., & Yao, Y. (2018). The Clinical Significance and Potential Role of C-Reactive Protein in Chronic Inflammatory and Neurodegenerative Diseases. *Frontiers in Immunology*, *9*. https://doi.org/10.3389/fimmu.2018.01302
6. Winstein, C. J., Stein, J., Arena, R., Bates, B., Cherney, L. R., Cramer, S. C., ... & Zorowitz, R. D. (2016). Guidelines for adult stroke rehabilitation and recovery: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*, *47*(6), e98-e169. https://doi.org/10.1161/STR.0000000000000098
7. Billinger, S. A., Arena, R., Bernhardt, J., Eng, J. J., Franklin, B. A., Johnson, C. M., MacKay-Lyons, M., Macko, R. F., Mead, G. E., Roth, E. J., Shaughnessy, M., & Tang, A. (2014). Physical Activity and Exercise Recommendations for Stroke Survivors. *Stroke*, *45*(8), 2532–2553. https://doi.org/10.1161/str.0000000000000022
8. Faraci, F. M., & Didion, S. P. (2004). Vascular protection: superoxide dismutase isoforms in the vessel wall. *Arteriosclerosis, thrombosis, and vascular biology*, *24*(8), 1367-1373. https://doi.org/10.1161/01.ATV.0000133604.20182.cf
9. Wu, F., Liu, Z., Zhou, L., Ye, D., Zhu, L.-M., Huang, K.-Y., Weng, Y., Xiong, X., Zhan, R., & Shen, J. (2022). Systemic immune responses after ischemic stroke: From the center to the periphery. *Frontiers in Immunology* , *13*. https://doi.org/10.3389/fimmu.2022.911661
10. Ridker, P. M., & Rane, M. (2021). Interleukin-6 Signaling and Anti-Interleukin-6 Therapeutics in Cardiovascular Disease. *Circulation Research*, *128*(11), 1728–1746. https://doi.org/10.1161/circresaha.121.319077
11. Dromerick, A. W., Edwards, D. F., & Hahn, M. (2000). Does the Application of Constraint-Induced Movement Therapy During Acute Rehabilitation Reduce Arm Impairment After Ischemic Stroke? *Stroke*, *31*(12), 2984–2988. https://doi.org/10.1161/01.str.31.12.2984
12. Saunders, D. H., Greig, C. A., & Mead, G. E. (2014). Physical Activity and Exercise After

Stroke. *Stroke*, *45*(12), 3742–3747. https://doi.org/10.1161/strokeaha.114.004311

13. Li, F., Geng, X., Huber, C., Stone, C., & Ding, Y. (2020). In Search of a Dose: The Functional and Molecular Effects of Exercise on Post-stroke Rehabilitation in Rats. *Frontiers in Cellular Neuroscience*, *14*. https://doi.org/10.3389/fncel.2020.00186
14. Raskin, S. A. (Ed.). (2011). *Neuroplasticity and rehabilitation*. Guilford Press.
15. Liu, Y., Li, J., Guo, H., Chao, F., Yang, Q., Qin, W., ... & Zhang, K. (2024). Nanomaterials for stroke diagnosis and treatment. *iScience*. https://www.cell.com/iscience/fulltext/S2589-0042(24)02337-X
16. Couch, C., Mallah, K., Borucki, D. M., Bonilha, H. S., & Tomlinson, S. (2021). State of the science in inflammation and stroke recovery: A systematic review. *Annals of Physical and Rehabilitation Medicine*, *65*(2), 101546–101546. https://doi.org/10.1016/j.rehab.2021.101546
17. Guo, J., Su, W., Fang, J., Chen, N., Zhou, M., Zhang, Y., & He, L. (2018). Elevated CRP at admission predicts post-stroke cognitive impairment in Han Chinese patients with intracranial arterial stenosis. *Neurological Research*, *40*(4), 292–296. https://doi.org/10.1080/01616412.2018.1438224
18. Saceleanu, V. M., Toader, C., Ples, H., Covache-Busuioc, R.-A., Costin, H. P., Bratu, B.-G., Dumitrascu, D.-I., Bordeianu, A., Corlatescu, A. D., & Ciurea, A. V. (2023). Integrative Approaches in Acute Ischemic Stroke: From Symptom Recognition to Future Innovations. *Biomedicines*, *11*(10), 2617. https://doi.org/10.3390/biomedicines11102617
19. Pandita, R., & Patel, R. (2024). Unmet needs need to be met in Post-Stroke Management in India. *Authorea Preprints*.
20. Shimony, N., Martinez-Sosa, M., Osburn, B., & Jallo, G. I. (2021). Non-traumatic pediatric intracranial hypertension: key points for different etiologies, diagnosis, and treatment. *Acta Neurologica Belgica*, *121*, 823-836. https://doi.org/10.1007/s13760-021-01626-0
21. Kasapis, C., & Thompson, P. D. (2005). The effects of physical activity on serum C-reactive protein and inflammatory markers: a systematic review. *Journal of the American College of Cardiology*, *45*(10), 1563–1569. https://doi.org/10.1016/j.jacc.2004.12.077