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The silent burden in rural India: A comprehensive study of migraine frequency, sleep quality and polysomnographic characteristics among migraine patients

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Abstract:
Migraine is a leading cause of disability, but links between attack frequency, subjective sleep quality and objective sleep architecture remain unstudied in rural India. This cross-sectional study assessed 142 ICHD-3 migraine patients using the Pittsburgh Sleep Quality Index (PSQI) and overnight polysomnography. Mean PSQI was 11.37±1.06, with 95.1% showing very poor sleep; architecture was markedly altered (efficiency 64.76%, N3 14.12%, REM 10.84%). Migraine frequency correlated with female gender and age (both $p<0.001$), while PSQI negatively correlated with sleep efficiency ($r=-0.316$). Thus, data support routine sleep screening and integrated care in resource-limited settings.

Keywords: Migraine, sleep quality, polysomnography, Pittsburgh sleep quality index (PSQI), REM sleep

Background:
Migraine is a complex neurological disorder affecting approximately 12% of the global population and ranking as the second leading cause of years lived with disability worldwide **[1, 2]**. In rural India, this burden is compounded by poor healthcare access, lack of specialist care and limited disease awareness, chronic migraine, defined as head pain on ≥15 days/month for ≥3 months, affects 1-2% of the population **[3]**. Sleep disorders are reported in 30-50% of migraine patients and poor sleep quality triggers attacks and adds to their aftermath **[4, 5]**. The hypothalamus, the brain's sleep-wake regulator, has emerged as a key player in migraine pathophysiology; Functional neuroimaging demonstrates hypothalamic activation during the premonitory phase of migraine, suggesting that sleep-wake disruption may precede headache development **[6, 7]**. The Pittsburgh Sleep Quality Index (PSQI) is a validated tool that allows us to better understand how patients perceive their sleep **[8]**. Scores > 5 indicate poor sleep quality and several studies have demonstrated that migraine patients score significantly higher than healthy controls **[9, 10]**. Polysomnography (PSG), the gold standard for objective sleep assessment, has demonstrated measurable changes in the sleep architecture of migraine patients-reduced sleep efficiency, reduced deep (N3) sleep and reduced REM sleep **[11]**. A study in 2025 demonstrated that the odds of having chronic migraine were over three times higher when rapid eye movement (REM) sleep was less than 23.1% of total sleep time (OR: 3.61, 95% CI: 1.60-8.15, p=0.002) **[12]**. Deep sleep (N3) is particularly important, as the glymphatic system that clears brain waste products is most active during N3 sleep **[13]**. Impaired clearance due to reduced N3 sleep may exacerbate cortical spreading depression and inflammatory mediator accumulation **[14]**. Rural Indian populations face particular challenges, with limited recognition of migraine as a medical condition and restricted healthcare access **[15]**. The estimated migraine prevalence in rural India is 14.2%, underscoring the need for comprehensive assessment **[16]**. Therefore, it is of interest to evaluate the frequency of migraine, assess sleep quality using the Pittsburgh Sleep Quality Index and evaluate polysomnographic characteristics among migraine patients in rural India and to examine the associations between these parameters.

Materials and Methods:

Study design and setting:
This hospital-based cross-sectional study was conducted at UPUMS, Saifai, Uttar Pradesh, from January 2024 to December 2025. Institutional Ethics Committee approval was obtained (Approval No. 18/2023-24). Written informed consent was obtained from all participants **[17]**.

Study population:
Patients aged 16-60 years diagnosed with migraine per ICHD-3 criteria **[3]** were included. Exclusion criteria included: other headache disorders; conditions affecting sleep; medications affecting sleep architecture within 4 weeks; major psychiatric disorders; substance use; pregnancy/lactation; and neurological disorders other than migraine **[18]**.

Sample size:
A total of 142 participants were enrolled through consecutive sampling from the neurology OPD. Sample size was calculated with 95% confidence, 80% power and effect size 0.30 **[19]**.

Clinical Assessment
Migraine was classified per ICHD-3 criteria. Chronic migraine was defined as headache ≥15 days/month for >3 months, with ≥8 days/month meeting migraine criteria. Frequency was categorized as: 1 (1-3/month), 2 (4-7/month), 3 (8-14/month), 4 (≥15/month) **[20]**.

Sleep quality assessment:
The PSQI was administered to all participants **[8]**. Global score >5 indicated poor sleep. Categories were: 0-5 (good), 6-10 (moderately poor), 11-21 (very poor) **[9, 10]**. Cronbach's α was 0.83 in Indian populations **[21]**.

Polysomnography:
Overnight PSG per AASM guidelines **[22]**. Sleep staging by certified technician blinded to diagnosis. Parameters: TST, SE (TST/total recording time × 100), N1%, N2%, N3%, REM% **[23]**.

Statistical analysis:
Data were analyzed using SPSS version 25.0. Continuous variables were expressed as mean±SD; categorical variables as n

(%). Comparisons were made using independent t-test, chi-square and one-way ANOVA with Tukey's HSD **[24]**. Correlations were assessed using Spearman's rank correlation. Significance was set at $p<0.05$ (two-tailed) **[25]**.

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Results:
Demographic and clinical characteristics, mean age 37.98 ± 11.15 years (range: 16-60). Males: 56 (39.4%), females: 86 (60.6%). Migraine without aura: 99(69.7%), with aura: 29(20.4%), chronic: 14(9.9%). Age distribution: 16-30 years (n=43, 30.3%), 31-45 years (n=60, 42.3%), 46-60 years (n=39, 27.5%). Migraine frequency: 1-3/month (n=9, 6.3%), 4-7/month (n=40, 28.2%), 8-14/month (n=54, 38.0%), ≥15/month (n=39, 27.5%) showed in **Table 1**. Gender significantly associated with migraine frequency ($\chi^2=25.58$, $p<0.001$). Females predominantly had ≥15/month (n=36, 41.9%), males predominantly 8-14/month (n=26, 46.4%) showed in **Figure 1**. Age group significantly associated with migraine frequency ($\chi^2=45.68$, $p<0.001$). The 31-45 years group had highest 8-14/month (n=32, 53.3%) in **Figure 2**. Mean PSQI: 11.37±1.06 (range: 8-14). Very poor sleep (PSQI 11-21):135(95.1%). Moderately poor (PSQI 6-10):7(4.9%) shown in **Figure 3**. No patient had good sleep quality. PSQI negatively correlated with sleep efficiency (r=-0.200, p=0.017) and positively with REM% (r=0.178, p=0.034). PSQI negatively correlated with N1% (r=-0.247, p=0.003) showed in **Table 2**. Polysomnographic findings, mean total sleep time (TST): 258.22 ± 88.72 minutes. Mean SE: 64.76±11.16% (range: 21.5-95.0%). Sleep stage distribution: N1 19.42±15.29%, N2 55.63±10.07%, N3 14.12±10.08%, REM 10.84±10.82% showed in **Table 3** and **Figure 4**. Correlation analysis revealed that migraine frequency was positively correlated with N2% (r=0.183, p=0.029). PSQI was negatively correlated with SE (r=-0.316, p<0.001) and positively correlated with REM% (r=0.187, p=0.026) shown in **Figure 5**. N1 strongly negatively correlated with N3 (r=-0.495, p<0.001) and REM (r=-0.778, p<0.001). N2 negatively correlated with N3 (r=-0.321, p<0.001) and REM (r=-0.238, p=0.004). SE negatively correlated with N2 (r=-0.216, p=0.010), N3 (r=-0.287, p=0.001) and REM (r=-0.220, p=0.009) showed in **Table 4 and Figure 6** and correlation heatmap in **Figure 7**. Spearman correlation heat map showing the relationships among migraine frequency, PSQI score sleep-stage percentages (N1, N2, N3, REM) and sleep efficiency (SE). Blue indicates positive correlations; red indicates negative correlations and darker colors represent stronger associations. Significant correlations are denoted by * ($p < 0.05$) and ** ($p < 0.01$). The strongest negative correlation was observed between N1 and REM sleep ($\rho = -0.778$, $p < 0.001$), while PSQI score showed a significant negative correlation with sleep efficiency ($\rho = -0.316$, $p < 0.001$).

Table 1: Demographic and clinical characteristics (N=142)

Characteristic	Total	Male (n=56)	Female (n=86)	p-value
Age (years, mean±SD)	37.98±11.15	38.0±13.1	35.8±11.7	0.228
Age Group, n (%)				0.182
16-30 years	43(30.3)	17(30.4)	26(30.2)	
31-45 years	60(42.3)	25(44.6)	35(40.7)	
46-60 years	39(27.5)	14(25.0)	25(29.1)	
Migraine Type, n (%)				0.618
Without Aura	99(69.7)	38(67.9)	61(70.9)	
With Aura	29(20.4)	12(21.4)	17(19.8)	
Chronic	14(9.9)	6(10.7)	8(9.3)	
Frequency/month, n (%)				**<0.001**
1-3	9(6.3)	7(12.5)	2(2.3)	
4-7	40(28.2)	20(35.7)	20(23.3)	
8-14	54(38.0)	26(46.4)	28(32.6)	
≥15	39(27.5)	3(5.4)	36(41.9)	

Table 2: PSQI scores and categories

PSQI Parameter	Value
Mean PSQI Score	11.37 ± 1.06
PSQI Range	8-14
PSQI Category, n (%)	
Moderately Poor (6-10)	7(4.9)
Very Poor (11-21)	135(95.1)

Table 3: Polysomnographic Parameters (N=142)

PSG Parameter	Minimum	Maximum	Mean ± SD
PSQI Total Score	8	14	11.37 ± 1.06
Sleep Efficiency (%)	21.5	95	64.76 ± 11.16
Total Sleep Time (min)	102	551	258.22 ± 88.72
N1 Sleep (%)	0.0	61.1	19.42 ± 15.29
N2 Sleep (%)	30.6	91.2	55.63 ± 10.07
N3 Sleep (%)	0.0	39.6	14.12 ± 10.08

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REM Sleep (%)	0.3	56.7	10.84 ± 10.82

Table 4: Correlation matrix with showing heatmap (spearman's rho)

Variables	Migraine Frequency	PSQI Score	N1%	N2%	N3%	REM%	SE%
Migraine Frequency	1.000	0.018	-0.024	0.183*	0.000	-0.063	-0.091
PSQI Score	0.018	1.000	-0.148	0.052	0.080	0.187*	-0.316**
N1%	-0.024	-0.148	1.000	-0.104	-0.495**	-0.778**	0.249**
N2%	0.183*	0.052	-0.104	1.000	-0.321**	-0.238**	-0.216**
N3%	0.000	0.080	-0.495**	-0.321**	1.000	0.360**	-0.287**
REM%	-0.063	0.187*	-0.778**	-0.238**	0.360**	1.000	-0.220**
SE%	-0.091	-0.316**	0.249**	-0.216**	-0.287**	-0.220**	1.000

**Correlation significant at p<0.05; **Correlation significant at p<0.01.*

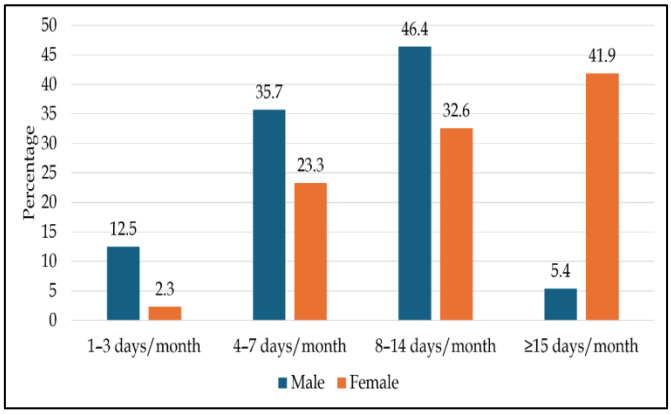


Figure 1: Migraine frequency by gender

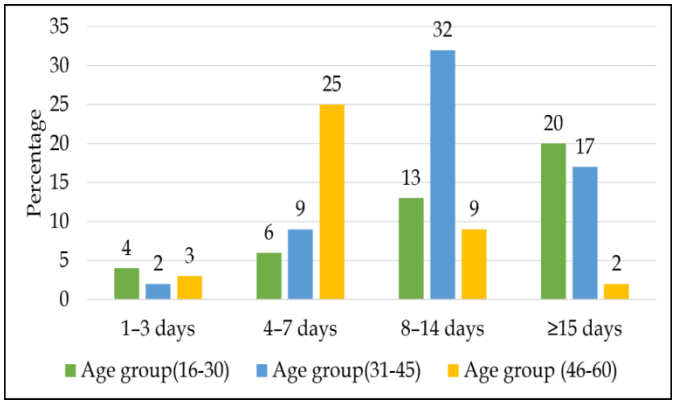


Figure 2: Migraine frequency by age group

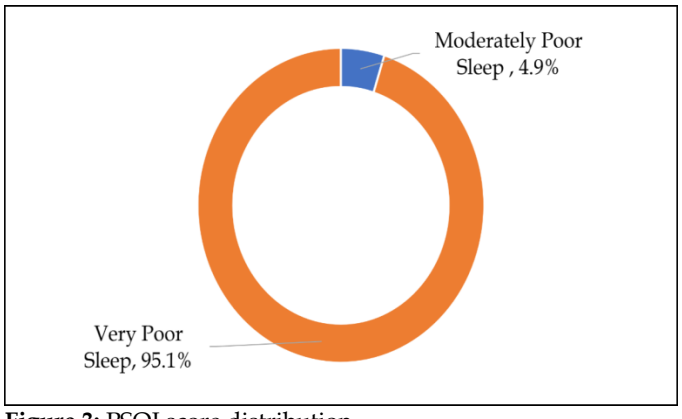


Figure 3: PSQI score distribution

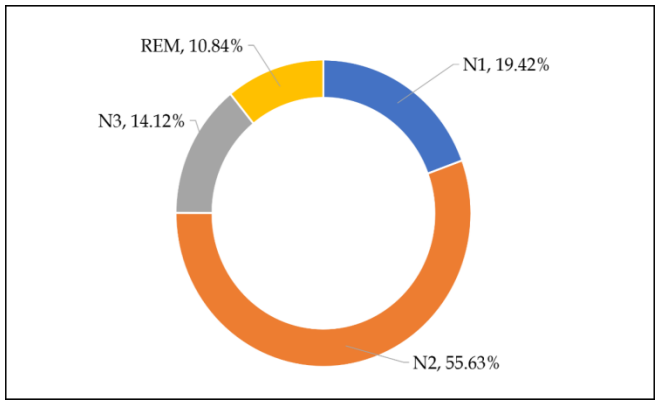


Figure 4: Sleep architecture distribution

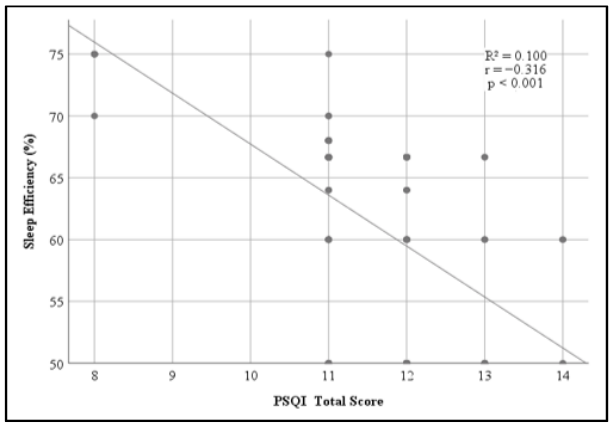


Figure 5: Relationship between PSQI score and sleep efficiency

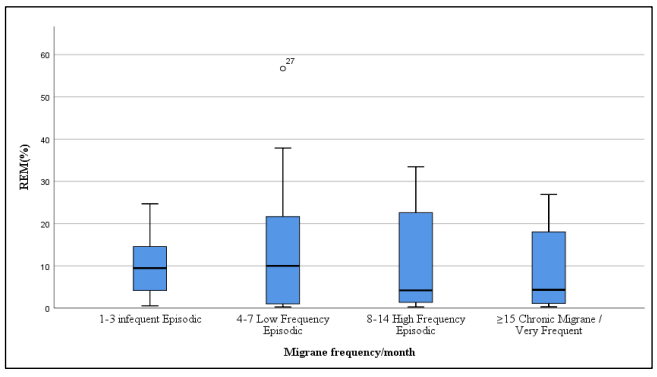


Figure 6: REM% by migraine frequency

Variables	Migraine Frequency	PSQI Score	N1%	N2%	N3%	REM%	SE%
Migraine Frequency	1.000	0.018	-0.024	0.183*	0.000	-0.063	-0.091
PSQI Score	0.018	1.000	-0.148	0.052	0.080	0.187*	-0.316**
N1%	-0.024	-0.148	1.000	-0.104	-0.495**	-0.778**	0.249**
N2%	0.183*	0.052	-0.104	1.000	-0.321**	-0.238**	-0.216**
N3%	0.000	0.080	-0.495**	-0.321**	1.000	0.360**	-0.287**
REM%	-0.063	0.187*	-0.778**	-0.238**	0.360**	1.000	-0.220**
SE%	-0.091	-0.316**	0.249**	-0.216**	-0.287**	-0.220**	1.000

Figure 7: Correlation heat map

Discussion:

This study evaluated sleep quality and polysomnographic characteristics in 142 rural Indian migraine patients. The findings are striking: 100% of patients had poor sleep quality (PSQI >5), with 95.1% having very poor sleep (PSQI 11-21)—far higher than the 57-75% reported previously **[9, 10]**. Mean PSQI (11.37 ± 1.06) exceeds the 7.98±3.69 reported in chronic migraine patients **[26]**. This stark difference is likely attributed to the unique rural challenges of limited healthcare access, environmental factors and cultural sleep practices **[15]**. The gender difference is striking. The frequency of migraine was significantly higher in females (≥15/month: 41.9 vs 5.4% in males; $\chi 2=25.58$, $p<0.001$) consistent with the known higher burden of migraine in women **[27]**. Women in rural India have a lot of domestic work and child rearing so they can be more stressed and have less time to relax. The 31-45 years age group had the highest proportion of patients with 8-14 headache days/month (53.3%) while the 46-60 years group predominantly had 4-7 headaches days/month (64.1%). This pattern reflects the natural history of migraine **[28]**. The persistence of frequent migraine into the 46-60 years age group suggests that many rural women may not experience the postmenopausal improvement commonly observed in Western populations. Polysomnography revealed severe sleep architecture disruption. The efficiency is only 64.76% and this means that the patients are awake almost one-third of the time they are in bed, a significant reduction from 78.1% in an urban study in 2025 **[12]**. Particularly concerning was the marked reduction of N3 sleep (14.12 ± 10.08%). N3 sleep is when the glymphatic system clears metabolic waste from the brain **[13]**. The reduction of N3 leads to an accumulation of neurotoxic substances, which can aggravate cortical spreading depression and increase pain sensitivity **[14]**. The most striking finding was the profound reduction of REM sleep. With only 10.84 ± 10.82% of TST, our patients had less than half of the REM sleep that healthy adults usually have (20-25%). REM below 23.1% of TST increases chronic migraine odds 3.6-fold **[12]**. The significant reduction of REM to 10.84% in our cohort is indicative of a high risk of migraine chronification. Correlation studies showed the interconnectedness of these disturbances. Migraine frequency was positively correlated with N2% ($r=0.183$, $p=0.029$) suggesting that high frequency migraine is associated with light sleep. Sleep efficiency was negatively correlated with PSQI ($r=-0.316$, $p<0.001$), indicating convergence of subjective perception with the objective reality. Negative correlations were seen for N1-REM ($r=-0.778$, $p<0.001$) and N1-N3 ($r=-0.495$, $p<0.001$) indicating that a higher light sleep correlates with less deep sleep and REM sleep.

Conclusion:

Migraine patients in rural India show exceptionally poor sleep quality (95.1% very poor; mean PSQI 11.37±1.06) and severely disrupted architecture (efficiency 64.76%, N3 14.12%, REM 10.84%). Gender and age significantly influenced migraine frequency and PSQI negatively correlated with sleep efficiency ($r=-0.316$, $p<0.001$). The marked REM reduction may promote pain sensitization and chronification, underscoring the urgent need for routine PSQI screening and integrated sleep care in rural Indian headache services.

Clinical implication:

The clinical practice should immediately focus on the poor sleep quality (95.1%) in rural Indian migraine patients. As pharmacotherapy is often the mainstay of treatment in resource-limited settings **[29]**, sleep hygiene practices should not be neglected and PSQI screening should be incorporated into routine migraine care. A five-minute PSQI assessment can identify patients who would benefit from sleep interventions. CBT-I reduces PSQI from 10.6 to 6.4 ($p<0.001$) and headache days from 7.8 to 4.2/month ($p=0.002$) **[30]**. Anti-CGRP monoclonal antibodies reduce PSQI from 8.913 to 6.491 at 3 months ($p<0.001$) **[31]**. Greater occipital nerve blockade has also shown promise in improving sleep quality in chronic migraine patients **[32]**.

Strengths:

First study combining PSQI and polysomnography in rural Indian migraine patients; objective PSG data; detailed clinical characterization.

Limitations:

Cross-sectional design; no healthy control group; hospital-based sampling; no psychiatric screening; no comorbid sleep disorder assessment.

Advancement of knowledge:

This study provides several significant contributions to the existing literature:

[1] **First Combined PSQI-PSG Study in Rural India:** This is the first study to comprehensively evaluate both subjective sleep quality (PSQI) and objective sleep architecture (polysomnography) in rural Indian migraine patients.

[2] **Quantification of Severe Sleep Disturbance:** The finding of 95.1% very poor sleep (mean PSQI 11.37±1.06) far exceeds previously reported rates (57-75%), establishing a baseline for future interventional studies.

[3] **Objective Documentation of REM Suppression:** Polysomnography revealed REM sleep (10.84%) less than half the normal proportion (20-25%), providing objective evidence for the biological basis of migraine chronification.

[4] **Gender and Age-Specific Rural Patterns:** Females had a 7.7-fold higher proportion of high-frequency migraine (≥15

days/month: 41.9% vs. 5.4% in males), suggesting postmenopausal improvement may not occur in rural Indian settings.

[5] Validation of PSQI as a Screening Tool: The significant correlation between PSQI and sleep efficiency (r=-0.316, p<0.001) validates PSQI as a practical screening tool in resource-limited settings.

[6] Identification of Therapeutic Targets: Strong correlations between N1-REM (r=-0.778) and N1-N3 (r=-0.495) identify specific sleep architecture abnormalities as therapeutic targets.

[7] Clinical Evidence for Glymphatic System Involvement: The marked N3 reduction (14.12%) provides clinical evidence supporting the connection between impaired glymphatic clearance and migraine pathophysiology.

[8] Evidence for Early Intervention: The progressive decline in REM sleep with increasing migraine frequency suggests sleep disruption is a modifiable risk factor requiring early intervention.

Abbreviations:

[1] AASM: American Academy of Sleep Medicine
[2] CGRP: Calcitonin Gene-Related Peptide
[3] ICHD-3: International Classification of Headache Disorders, Third Edition
[4] NREM: Non-Rapid Eye Movement
[5] PSG: Polysomnography
[6] PSQI: Pittsburgh Sleep Quality Index
[7] REM: Rapid Eye Movement

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Authors' contributions:
Prof. (Dr.) Anamika Singh, as the research guide, conceived and designed the study and supervised participant recruitment, data collection and clinical assessment. Dr. Shaila Kumari, as the main researcher, participated in participant recruitment, data collection, clinical assessment, performed statistical analysis, interpreted the findings, drafted the manuscript and critically revised it for important intellectual content. Dr. Raj Kamal Maurya critically revised the manuscript for important intellectual content. All authors approved the final version and agree to be accountable for all aspects of the work.

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Availability of data and materials:
The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate:
The study protocol was approved by the Institutional Ethics Committee of Uttar Pradesh University of Medical Sciences, Saifai, Uttar Pradesh, India (Approval No. 18/2023-24**)** the study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrolment.

Competing interests:
The authors declare that they have no competing interest

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