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The relationship between empathy and cognition in patients with tension type headache

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MAIN POINTS

- Empathy alterations in tension-type headache (TTH) patients occur independently of global cognitive performance.
- Female patients show higher affective empathy compared to males.
- Age is associated with decreased cognitive function but increased affective empathy.
- Executive dysfunction is linked to heightened emotional empathy in TTH.

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ABSTRACT

Aim: Tension-type headache (TTH) is the most common primary headache disorder, yet its impact on cognitive and empathic functions remains underexplored. This study investigates the relationship between cognitive domains and empathy in individuals with TTH, considering demographic influences.

Materials and Methods: A total of 71 TTH patients (49 females, 22 males) underwent cognitive assessment using the Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE), alongside the Empathy for Pain Scale (EPS) to evaluate cognitive and affective empathy. Statistical analyses included independent samples t-tests and Pearson correlation.

Results: No significant differences found were in terms of gender, general cognitive performance (MMSE, MoCA). However, females exhibited significantly higher affective distress, visceral pain empathy, and empathic concern scores. Males showed slower cognitive processing speed on the Trail Making Test. Age negatively correlated with cognitive function but positively with affective distress and empathic concern. Education was positively associated with cognitive scores but not with empathy measures. Executive dysfunction correlated with increased emotional empathy.

Conclusion: The findings reveal distinct gender-related differences in empathy among TTH patients, independent of global cognition, and highlight the complex interplay between executive function, age, education, and empathic processing. These insights underscore the need for integrative biopsychosocial approaches in TTH management.

Keywords: Headache, Cognitive impairment, Empathy, Pain

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INTRODUCTION

Tension-type headache (TTH) is the most prevalent primary headache disorder worldwide, characterized by bilateral, non-pulsating discomfort of mild to moderate intensity [1]. The etiology of TTH is considered multifactorial, involving a complex interplay between genetic predispositions and environmental influences [2]. For instance, Akcali et al. [3] suggested that polymorphisms in the serotonin transporter gene may be linked to TTH. Furthermore, musculoskeletal tension can be exacerbated by environmental stressors, poor urban living conditions, and suboptimal posture—all of which can prolong or aggravate headache symptoms [4, 5]. these multidimensional factors underscore the complex neurobiological and psychosocial underpinnings of TTH, highlighting the necessity of understanding how such influences affect higher-order psychological functions, including cognition and empathy.

While several studies have examined the cognitive and emotional consequences of migraine and neuropathic pain, TTH has received relatively little attention, particularly regarding its impact on empathic processes. This research gap may be attributed to a traditional focus on more debilitating headache forms, such as migraine, and the often-unrecognized long-term burden of TTH. Empathy is a critical social-cognitive ability that has been shown to be disrupted in various chronic pain conditions, potentially because pain-induced alterations

in cognitive processing interfere with these socio-emotional capacities [6].

In addition to these factors, the role of negative cognition—and the associated dysfunction of the anterior insula—is significant. Distorted thinking patterns, such as catastrophizing, hopelessness, and overgeneralization, are central to the cognitive domain of negative cognitions. Research suggests that such negative cognitions may generate as much distress as the subjective experience of chronic pain itself, emphasizing a profound emotional and cognitive dysregulation [7]. Although cognitive empathy is distinct from affective empathy—involving the mental construction or representation of another's experience—our study posits that disruptions to cognitive empathy may exist in TTH, potentially mediated by these maladaptive cognitive patterns.

Based on these findings, the present study aims to systematically explore the association between cognitive functions and empathy in individuals diagnosed with TTH. Specifically, we seek to determine whether alterations in executive functions, attention, and memory contribute to differences in cognitive and affective empathy compared to healthy controls. This study addresses the research problem that the cognitive–emotional interplay underlying TTH remains poorly understood, which may hinder the development of holistic treatment approaches. We hypothesize that: (1) individuals with TTH will demonstrate reduced cognitive empathy compared to controls; (2) these differences will be associated with impairments in specific cognitive domains; and (3) maladaptive cognitive patterns may mediate the relationship between headache severity and empathy performance.

Consequently, this study investigates the relationship between key cognitive domains—including executive functioning, attention, and memory—and types of empathy (cognitive and affective) using the Empathy for Pain Scale in TTH subjects [8]. By identifying potential cognitive mediators of empathy alterations in this population, we aim to broaden the understanding of TTH beyond its somatic manifestations toward a more comprehensive biopsychosocial model of care.

MATERIALS AND METHODS

Study design and participants

This is a prospective observational study. We included 71 patients diagnosed with tension-type headache (TTH) who were followed up at the Neurology Department of Alanya Training and Research Hospital between February 2023 and May 2024. The study was approved by the Ethics Committee of Alanya Alaaddin Keykubat University (ethics no: 16072023/289) and conducted in accordance with the Declaration of Helsinki and the guidelines outlined in the STROBE statement [9].

Diagnosis and grouping procedure

The diagnosis of TTH was established in accordance with the International Classification of Headache Disorders, 3rd edition (ICHD-3) criteria. Specifically, patients were required to present with bilateral location, a pressing or tightening (non-pulsating) quality, mild-to-moderate intensity, and a lack of aggravation by routine physical activity [10]. To ensure high diagnostic accuracy and minimize variability, all patients were evaluated by a neurology specialist with a minimum of five years of experience. This process involved structured clinical interviews and the application of standardized symptom criteria.

As this was an observational study, no randomization procedures were utilized for participant allocation; instead, all eligible patients meeting the predefined inclusion criteria were consecutively enrolled. Furthermore, blinding (masking) was not implemented, as the study design did not involve an interventional protocol or a specific control group comparison.

Assessment tools

The study employed the Montreal Cognitive Assessment (MoCA) [11] and the Mini-Mental State Examination (MMSE) [12] to evaluate global cognitive functioning. Both tools are well validated and frequently used in chronic pain populations to assess cognitive impairment [13].

As part of the visuospatial/executive subscale of the MoCA, the Trail Making Test Parts B (TMT) was administered to assess executive function, visual attention, and cognitive processing speed. Lower performance on the TMT reflects reduced mental flexibility and diminished executive control, which are often affected in patients with chronic pain or attentional deficits.

In addition, the Empathy for Pain Scale (EPS) was used to assess pain-specific cognitive and affective empathy [14]. Specific cognitive domains assessed included visual reconstruction, attention, sentence repetition, delayed recall, orientation, verbal fluency, naming, and abstract thinking [14,15]. Data related to age and educational status were recorded to control for potential confounding effects on cognitive and empathy outcomes [16]. State empathy, need-to-help, and compassion questions were used to evaluate empathic concern (EC), whereas affective distress (AD) was assessed using

Table 1. Demographic characteristics of patients.

		Percentage (%)
Age (Mean ± SD Range)	19-67 years (40.5 ± 13.2)	
Gender		
Male	22	30.9
Female	49	69
Education Status		
Primary School	24	33.8
Middle School	9	12.6
High School	21	29.5
University	17	23.9

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Table 2. Summary of the analyses empathy and cognitive parameters according to gender.

Parameter	Female (Mean ± SD)	Male (Mean ± SD)	Levene's Test (p)	t-Test (p)
MMSE	28.6 ± 2.52	29 ± 1.57	0.201	0.508
MOCA	21.6 ± 4.53	23.5 ± 3.19	0.016	0.073
Visceral Pain	20 ± 10.8	11.4 ± 4.83	< 0.001	< 0.001
Affective Distress	86.2 ± 23.91	62.5 ± 13.84	0.014	< 0.001
Empathic Concern	50 ± 8.64	43.40 ± 10.7	0.162	0.007
Trail Making Test	0.59 ± 0.49	0.86 ± 0.35	< 0.001	0.024
Visuospatial	3.06 ± 1.10	3.45 ± 1.05	0.607	0.280
Naming	2.42 ± 0.67	2.50 ± 0.51	0.089	0.162
Attention	5.16 ± 1.10	5.54 ± 0.59	0.325	0.251
Sentence repetition	0.81 ± 0.83	0.77 ± 0.86	0.682	0.217
Verbal Fluency	0.61 ± 0.49	0.63 ± 0.49	0.694	0.126
Abstract Thinking	1.06 ± 0.82	1.18 ± 0.73	0.398	0.205
Memory	1.79 ± 1.51	2.63 ± 1.46	0.979	0.385
Orientation	5.71 ± 0.61	5.77 ± 0.68	0.672	0.163

This table presents mean and standard deviation values for neuropsychological test scores (MMSE, MOCA, MoCA subdomains), visceral pain, affective distress, and empathic concern between female and male participants. Levene's Test was used to assess homogeneity of variances, and the independent samples t-test was used to evaluate between-group differences. Values of $p < 0.05$ were considered statistically significant.

items addressing fear, distress, discomfort, disgust, restlessness, avoidance, and visceral sensations.

Primary outcome measures

The primary outcome variables were global cognitive scores (MoCA and MMSE) and empathy scores (EPS total, cognitive empathy, and affective empathy subscales). Secondary outcomes comprised Trail Making Test (TMT) scores, utilized as indicators of executive processing speed and cognitive flexibility, alongside the associations among these cognitive domains and various empathy parameters.

Statistical analysis

Statistical analyses were conducted using Jamovi software (version 2.3.28; GNU General Public License). Prior to analysis, all data were rigorously screened for completeness and accuracy. The normality of distribution for numerical variables was evaluated using the Shapiro–Wilk test. Continuous variables are presented as mean ± standard deviation (SD), while categorical variables are reported as frequencies and percentages.

For hypothesis testing, the independent samples t-test was employed to compare mean values between groups (e.g., gender), contingent upon the assumptions of normal distribution and homogeneity of variances, the latter of which was assessed via Levene's test. Pearson's correlation analysis was performed to examine the associations between empathy scores and cognitive measures. For all statistical evaluations, a p-value < 0.05 was established as the threshold for significance.

To validate the study's findings, a post hoc power analysis was conducted using G*Power (version 3.1.9.3, Universität Düsseldorf, Germany). With an alpha level of 0.05 and a large effect size (Cohen's d = 0.8), the analysis yielded a statistical power of 0.97, confirming that the sample size was sufficient to detect large effects with high reliability.

RESULTS

A total of 71 patients diagnosed with tension-type headache (TTH) were included in the study, comprising 49 females (69.0%) and 22 males (30.9%). The mean age of the participants was 40.5 ± 13.2 years (range: 19–67 years). Educational distribution was as follows: 33.8% were primary school graduates, 12.6% middle school, 29.5% high school, and 23.9% university graduates (Table 1).

Gender differences

Independent samples t-tests revealed significant gender-related differences in several empathy and executive parameters (Table 2). Before applying the t-tests, variance homogeneity was confirmed using Levene's test, ensuring that group comparisons met the assumption of equal variances.

Females demonstrated significantly higher Affective Distress (AD) scores (86.2 ± 23.91 vs. 62.5 ± 13.84, $p < 0.001$), higher Visceral Pain (VP) scores (20.0 ± 10.8 vs. 11.4 ± 4.83, $p < 0.001$), and greater Empathic Concern (EC) (50.0 ± 8.64 vs. 43.4 ± 10.7, $p = 0.007$) compared with males.

No significant gender differences were found in global cognitive performance, as measured by MMSE ($p = 0.508$) or MoCA ($p = 0.073$). However, a significant difference was detected in TMT scores, with males exhibiting higher mean values (0.86 ± 0.35) compared to females (0.59 ± 0.49, $p = 0.024$), suggesting slower executive processing in females.

No statistically significant differences were observed in other cognitive subdomains, including visuospatial ability ($p = 0.280$), naming ($p = 0.162$), attention ($p = 0.251$), sentence repetition ($p = 0.217$), verbal fluency ($p = 0.126$), abstract thinking ($p = 0.205$), memory ($p = 0.385$), and orientation ($p = 0.163$) (Table 2).

Correlation analysis

As presented in Table 3, age demonstrated a negative correlation with both MoCA ($r = -0.406$, $p < 0.001$) and MMSE

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Table 3. Correlation between parameters such as education year, age, cognitive tests and empathic parameters.

According to Sociodemographic Variables			
Variable 1	Variable 2	r	p
Age	MOCA	-0.406	< .001
Age	MMSE	-0.250	0.035
Age	Tracking Test	-0.363	0.002
Age	Visuospatial	-0.226	0.058
Age	Naming	-0.027	0.825
Age	Attention	-0.202	0.091
Age	Repeat Sentences	-0.235	0.049
Age	Verbal Fluency	-0.073	0.546
Age	Abstract Thinking	-0.315	0.007
Age	Memory	-0.412	< .001
Age	Orientation	-0.229	0.055
Age	AD	0.285	0.016
Age	EC	0.290	0.014
Age	VP	0.126	0.297
Education	MOCA	0.596	< .001
Education	MMSE	0.347	0.003
Education	Tracking Test	0.369	0.002
Education	Visuospatial	0.585	< .001
Education	Naming	0.348	0.003
Education	Attention	0.327	0.005
Education	Repeat Sentences	0.346	0.003
Education	Verbal Fluency	0.478	< .001
Education	Abstract Thinking	0.388	< .001
Education	Memory	0.361	0.002
Education	Orientation	0.221	0.063
Education	AD	-0.135	0.260
Education	EC	-0.098	0.417
Education	VP	-0.119	0.323
According to Cognitive and Empathic Scores			
Variable 1	Variable 2	r	p
MOCA	MMSE	0.684	< .001
MOCA	AD	-0.148	0.218
MOCA	EC	0.104	0.386
MOCA	VP	−0.244	0.040
MMSE	Tracking Test	0.373	0.001
MMSE	Visuospatial	0.462	< .001
MMSE	Naming	0.298	0.012
MMSE	Attention	0.667	< .001
MMSE	Repeat Sentences	0.326	0.006
MMSE	Verbal Fluency	0.294	0.013
MMSE	Abstract Thinking	0.237	0.046
MMSE	Memory	0.284	0.017
MMSE	Orientation	0.799	< .001
MMSE	AD	-0.249	0.036
MMSE	EC	0.104	0.388
MMSE	VP	−0.293	0.013
Tracking Test	AD	-0.382	0.001
Tracking Test	EC	-0.211	0.077
Tracking Test	VP	−0.425	<.001

*MOCA: Montreal Cognitive Assessment Scale, MMSE: Minimental State Examition, AD: Affective Distress, VP: Visceral Pain, EC: Emphatic Concerne r: correlation coefficient.

(r = −0.250, p = 0.035) scores, indicating that cognitive performance declined with advancing age. Conversely, age correlated positively with Affective Distress (r = 0.285, p = 0.016) and Empathic Concern (r = 0.290, p = 0.014), reflecting increased emotional empathy in older individuals.

Education level was positively associated with cognitive test performance, including MoCA (r = 0.596, p < 0.001) and MMSE (r = 0.347, p = 0.003), but not significantly related to empathy parameters (p > 0.05).

Cognitive-executive measures showed inverse associations with emotional empathy: TMT scores correlated negatively with Affective Distress (r = −0.382, p = 0.001) and Visceral Pain (r = −0.425, p < 0.001), indicating that lower executive efficiency was associated with stronger emotional reactivity. Subgroup analyses further suggested that lower education intensified the relationship between cognitive impairment and empathic distress (Table 3).

DISCUSSION

This study investigated the relationships among empathy, cognition, and demographic factors in patients with Tension-type headache (TTH), revealing significant gender-based disparities, age-related patterns, and the moderating effects of education. Regarding empathic dimensions, female participants scored significantly higher in Vicarious Pain (VP), Affective Distress (AD), and Empathic Concern (EC). These findings align with previous literature suggesting that females generally demonstrate higher emotional responsiveness and empathic concern [8, 17]. Decety and Jackson [17] proposed a social-neuroscience framework wherein empathy integrates cognitive and affective processes, while Christov-Moore et al. [8] provided empirical evidence for gender-related variations in both neural activity and behavioral expression. Together, these perspectives suggest that while empathy relies on shared neurobiological systems, it is modulated by sex-dependent mechanisms.

Hormonal influences may also play a role; estrogen has been linked to enhanced emotional processing through prefrontal–limbic modulation [18], whereas testosterone may attenuate empathic distress [19]. Interestingly, while gender differences in empathy were pronounced, they did not extend to global cognitive performance as measured by MMSE and MoCA. However, males demonstrated superior performance on the Trail Making Test (TMT), reflecting more efficient executive processing speed and flexibility.

Age emerged as another significant influential factor in our cohort. Older participants exhibited higher AD and EC but lower MMSE and MoCA scores, aligning with findings that affective empathy tends to remain stable or even increase with age, whereas cognitive functions typically decline [20]. The inverse association between cognitive scores and empathy observed here suggests a potential trade-off, possibly reflecting diminished prefrontal regulation of emotional responses in older populations. The finding that reduced executive functioning was associated with heightened affective empathy further supports the hypothesis that decreased cognitive control may enhance emotional reactivity. Consequently, interventions such as cognitive training or mindfulness-based practices may be beneficial in regulating empathic distress in TTH populations [21].

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Furthermore, educational attainment correlated positively with cognitive outcomes but not with empathy, supporting the cognitive reserve hypothesis, which suggests that higher education mitigates the impact of cognitive decline on broader social cognition [22]. From a neurobiological perspective, empathy involves the mirror neuron system and the prefrontal cortex [23]. These systems may be altered in TTH due to functional connectivity changes within pain-processing networks [24]. Chronic pain may further modulate the hypothalamic–pituitary–gonadal (HPG) axis, thereby influencing empathic behavior through specific neuroendocrine pathways.

The clinical implications of these findings are substantial. Enhancing cognitive flexibility and executive control through structured cognitive or empathy-focused interventions may mitigate empathic distress and improve emotional regulation in patients with TTH. Programs such as Cognitive-Behavioral Therapy (CBT), Mindfulness-Based Stress Reduction (MBSR), or compassion training could alleviate the psychosocial burden associated with chronic pain. Additionally, psychoeducation regarding empathy regulation may assist patients in developing adaptive coping strategies, ultimately improving quality of life. Future research should utilize larger, more diverse cohorts and employ longitudinal designs to establish causal relationships. Incorporating hormonal assays and neuroimaging assessments is warranted to further elucidate the underlying neurobiological mechanisms, and intervention-based studies are needed to test the efficacy of cognitive and empathic training protocols in TTH populations.

Limitations

This study has several limitations that should be acknowledged. First, the relatively small sample size may limit the generalizability of the findings to broader populations. Second, the cross-sectional design precludes the ability to draw causal inferences regarding the relationships between cognitive and empathic measures. Third, while validated instruments were utilized, the reliance on self-report scales introduces the potential for reporting bias and social desirability bias.

Furthermore, comorbid psychiatric symptoms—such as depression, anxiety, and other affective disorders—were not specifically assessed or statistically controlled in this study. Given that these conditions are known to influence both empathy and cognitive performance, their omission represents a potential confounding factor. Finally, hormonal fluctuations and medication use were not systematically monitored; these variables could further influence emotional and cognitive outcomes and should be considered in future research.

FUTURE DIRECTIONS

Future studies should overcome this by including healthy controls and employing a longitudinal design to track the fluctuation of empathy and cognition. Advanced neuroimaging techniques and hormonal profiling could give further mechanistic insights. Further, investigating the role of culture and psychosocial modulation may yield valuable perspectives in empathic responses.

Ethics Committee Approval: The study was approved by the Alanya Alaaddin Keykubat University Non-Interventional Clinical Research Ethics Committee (Decision number: 16072023/289).

Informed Consent: This prospective study was approved by the institutional ethics committee. All participants provided written informed consent in accordance with human ethics regulations before data collection began.

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