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The effect of physical therapy integrated with pharmacotherapy on tension-type headache and migraine in children and adolescents

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Abstract

Background Tension-type headache (TTH) and migraine are prevalent neurological conditions in children and adolescents that significantly impact activity of daily living (ADL) and quality of life (QOL). Although physical therapy targeting cervical myofascial trigger points (MTrPs) on TTH and migraine has been extensively studied in adults, the efficacy in pediatric patients remains unexplored. The aim of this study is to reveal the effect of physical therapy integrated with pharmacotherapy on TTH and migraine in children and adolescents.

Methods We conducted a prospective, observational cohort study recruiting consecutive patients aged 6 to 18 years with TTH and migraine with cervical MTrPs. They were classified into 4 types of headaches: frequent episodic TTH (FRTTH), chronic TTH (CTTH), episodic migraine (EM) and chronic migraine (CM). The once-weekly 40-minutes physical therapy session integrated with pharmacotherapy (integrated physical therapy) was continued until the treatment goals (headache days per week less than 2 days, headache impact test-6 (HIT-6) score to below of 50, and the ability to attend school daily) was achieved. Multifaceted assessments including headache frequency (headache days per week), headache intensity using the Visual Analogue Scale (VAS), pain catastrophizing score (PCS), hospital anxiety and depression scale (HADS) score, HIT-6 scores, and EuroQol 5 dimensions 5-level questionnaire (EQ-5D-5 L) scores, were conducted to evaluate the treatment effects.

Results 161 patients were enrolled in this study. 106 patients (65.8%) were diagnosed with TTH: 70 (66.8%) with FETHH, 36 (34.0%) with CTTH, and 55 patients (34.2%) were diagnosed with migraine: 43 patients (78.2%) with EM, 12 patients (21.8%) with CM. We observed significant improvements in headache frequency, headache intensity, PCS, HADS score, HIT-6 scores, and EQ-5D-5 L scores before and after the treatment in all 4 types of headaches. The average number of sessions required to achieve the treatment goals was 4 times (weeks) for patients with FETTH and EM, 5.5 for those with CTTH, and 7.5 for those with chronic migraine.

Conclusion The integrated physical therapy on pediatric TTH and migraine patients with the cervical MTrPs was significantly effective in reducing headache symptoms and improving ADL and QOL.

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Keywords Headache, Migraine, Tension-type headache, Children, Adolescents, Pediatric, Physical therapy, Physiotherapy, Myofascial trigger points

Introduction

Primary headaches, encompassing tension-type headache (TTH) and migraine, are the most prevalent neurological conditions affecting children and adolescents [1, 2]. The associated symptoms significantly impair activity of daily living (ADL) and quality of life (QOL) by restricting social and physical activities, increasing school absenteeism, contributing to poorer learning outcomes, elevating the risk of school dropout, and adversely affecting future career prospects [3, 4]. A synthesis of 64 cross-sectional epidemiological studies, conducted between 1988 and 2013 and involving 227,249 children and adolescents, revealed an average headache prevalence of 54.4%, with a mean prevalence of migraine of 9.1% [1]. A separate study in Japan found that 49.4% of elementary and junior high school students aged 6–15 years experienced headaches, with incidences of TTH and migraine of 16.6% and 8.5%, respectively [5].

The management of primary headaches in children and adolescents necessitates a multifaceted and interdisciplinary approach encompassing pharmacotherapy, physical therapy, cognitive behavioral therapy, and lifestyle modification. A systemic review focusing on the pharmacotherapy of TTH and migraine indicated the existence of multiple pharmacological alternatives, but robust, high-quality evidence is limited to just a few agents, and no medication has received approval specifically for the prevention of primary headaches in children and adolescents [6]. As a result, the integration of non-pharmacological interventions is crucial when creating comprehensive treatment plans for primary headaches in children and adolescents.

Neck pain with myofascial trigger points (MTrPs) is highly prevalent in adults and children with both TTH and migraine [7–11]. MTrPs are defined as hyperirritable spots in the skeletal muscle associated with hypersensitive palpable nodules within taut bands [12]. Their role in the pathophysiology of TTH and migraine remains unclear [13]. According Travell and Simons's comprehensive trigger point manual, cervical MTrPs are associated with greater occipital nerve compression via semispinalis capitis contraction, and cervical MTrP manual therapy effectively treats both TTH and migraine [12–15]. The greater occipital nerve innervates the sensory of occipital and parietal region to the vortex, and gives rise to the second cervical dorsal nerve root and projects to the spinal trigeminal nucleus [16, 17]. The greater occipital nerve also connects the first and third cervical nerves through the Cruveilhier plexus which comprises interneural connections between the dorsal roots of the upper cervical spinal nerves [18]. Although the first cervical spinal cord has generally been considered to have no significant sensory function, cadaveric studies indicate that the first cervical dorsal root was present in 46.6% of specimens, and that 28.5% had a dorsal root ganglion [19]. The first cervical dorsal root may be an important therapeutic target for migraine [20]. Some reports have indicated that greater occipital nerve blockade or stimulation was effective as a preventive treatment for CM [21–23]. A recent report demonstrated that repetitive neuromuscular magnetic stimulation on cervical MTrPs was effective for treating pediatric headache disorders [24] .

The effect of physical therapy for TTH and migraine in adults is well-documented and systematically reviewed [25–30]. We have also achieved favorable outcome by physical therapy combined with pharmacotherapy (combined physical therapy) for TTH and migraine in adults resistance to preventive pharmacotherapy [31]. We have observed that the high prevalence of cervical MTrPs in pediatric patients with TTH and migraine similar to adult patients [13]. For these pediatric patients, we have initiated treatment with physical therapy, that was simultaneously integrated with pharmacotherapy (integrated physical therapy). To the best of our knowledge, this study is the first to investigate the effect of integrated physical therapy for treating TTH and migraine in children and adolescents.

Methods

Study design and ethics

This was a prospective, single-center, observational cohort study. The participant enrollment period spanned 1 year, followed by a maximum observation duration of 6 months post-registration. The study received approval from the Sakai Neurosurgical Clinical Research Ethics Committee (approval number: SNC2023-01). Comprehensive information regarding the study was provided to all participants and their parents, and informed written consent was duly obtained. The study's protocols adhered to the principals outlined in the Declaration of Helsinki.

Patients

From July 2022 to June 2023, we initially recruited consecutive patients aged 6 to 18 years with TTH and migraine with the presence of MTrP in the upper cervical spine (C1 and/or C2). All participants met the diagnostic criteria for TTH or migraine as outlined in the 3rd edition of the International Classification of Headache Disorders (ICHD-3) [32]. They were classified into 4 types of headaches: frequent episodic TTH (FRTTH), chronic

TTH (CTTH), episodic migraine (EM) and chronic migraine (CM). We excluded patients with infrequent episodic TTH and patients with concomitant orthostatic dysregulation including orthostatic hypotension (OH) and postural orthostatic tachycardia syndrome (POTS). To exclude intracranial pathologies, MR imaging and MR angiography or CT scans were used to confirm the absence of intracranial lesions. Additionally, cervical spinal plain X-ray data were collected to confirm the absence of cervical spine lesions and to assess the prevalence of loss of physiological cervical lordosis and lateral bending.

Multifaceted assessments (Fig. 1)

The multifaceted assessments encompassed sensory, physical, and psychological measures, as well as evaluations of activities of ADL and QOL. Before treatment initiation, the baseline assessments were conducted. These included recording headache frequency (the number of headache days per weeks) through patient-maintained paper diaries and measuring headache intensity using the Visual Analogue Scale (VAS). Cervical MTrP were identified through palpation and compression of taut bands in the muscles [12]. Headache location as referred pain was documented through drawing. The range of motion in the cervical spine was measured using an Easy-Angle Digital Goniometer. Psychological response and state were evaluated using the Pain Catastrophizing Scale (PCS) and the Hospital Anxiety and Depression Scale (HADS). ADL was assessed by using the Headache Impact Test 6 score (HIT-6) questionnaire, which was designed to gage the impact of headaches on daily functioning. The EuroQol 5-Dimensions 5-Levels (EQ-5D-5 L) questionnaire was used to assess QOL. School absenteeism was verified during the consultation. The outcome assessments were conducted using the same evaluation parameters as the baseline assessments. In cases where the treatment period exceeded 1 month, the outcome assessments were performed at the 1-month mark and during the final sessions. We set the final session when the treatment goals (a reduction in headache frequency to less than twice a week, HIT-6 score of below of 50, and the ability to attend school daily) was achieved.

Integrated physical therapy

The integration of physical therapy with pharmacotherapy introduces a potential synergistic effect that could reduce the overall treatment duration. This integrated approach was conducted via close collaboration between a physician and physical therapists trained in pain rehabilitation techniques at Seirei Christopher University's Graduate Program. Initially, patients underwent

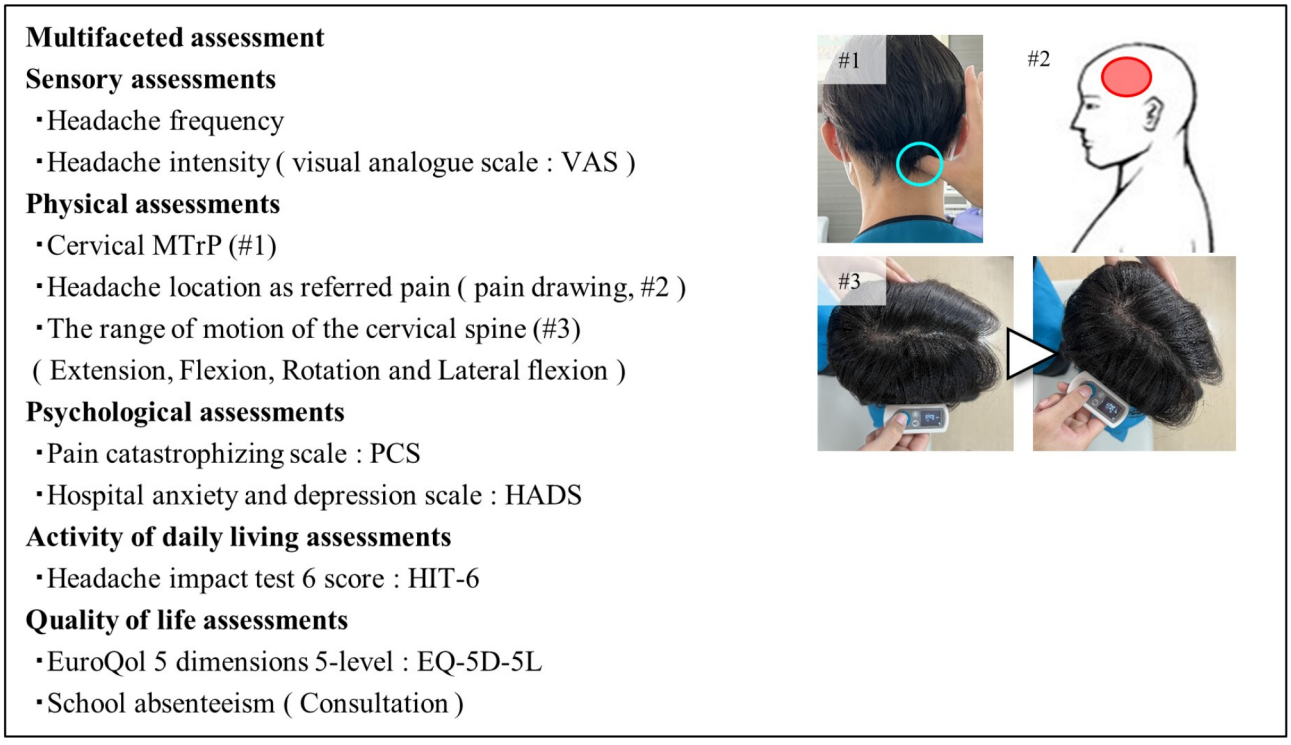

Fig. 1 Multifaceted assessments. #1) Assessing cervical myofascial Trigger points (MTrP): Applying manual compression to MTrP to determine the presence or absence of referred pain. #2) Assessing headache locations: instructing patients to illustrate the areas in which they experienced headache on a diagram of the human body. #3) Assessing the range of motion of the cervical spine using the Easy-Angle Digital Goniometer (Ito Ultrashortwave Co., Ltd.). The device is positioned on the head to measure the mobility of the cervical region

once-weekly physical therapy sessions, each lasting approximately 40 min. The primary components of this therapy were cervical MTrP manual therapy and cervical spine mobilization. Specific techniques incorporated the myofascial release of cervical muscles (notably the semispinalis capitis, suboccipital, upper trapezius, sternocleidomastoid, and splenius capitis), ischemic compression at MTrP, and the manual correction of cervical spine malalignment (Fig. 2). Additionally, patients were instructed to perform the neck and shoulder exercise composed of cervical MTrP massage, scapular training, pectoral stretching and shoulder exercise twice daily (Fig. 3). We recommended a 20–30 min outdoor brisk walking for 5 days per week as an aerobic exercise. The treatment goal for the once-weekly integrated physical therapy were set as follows: a reduction in headache frequency (the number of days with headache) to less than twice a week, a HIT-6 score of below 50, and the ability to attend school daily without school presenteeism and absenteeism. The outcome measures were collected through paper diaries and question about school absenteeism to patients conducted at the beginning of each

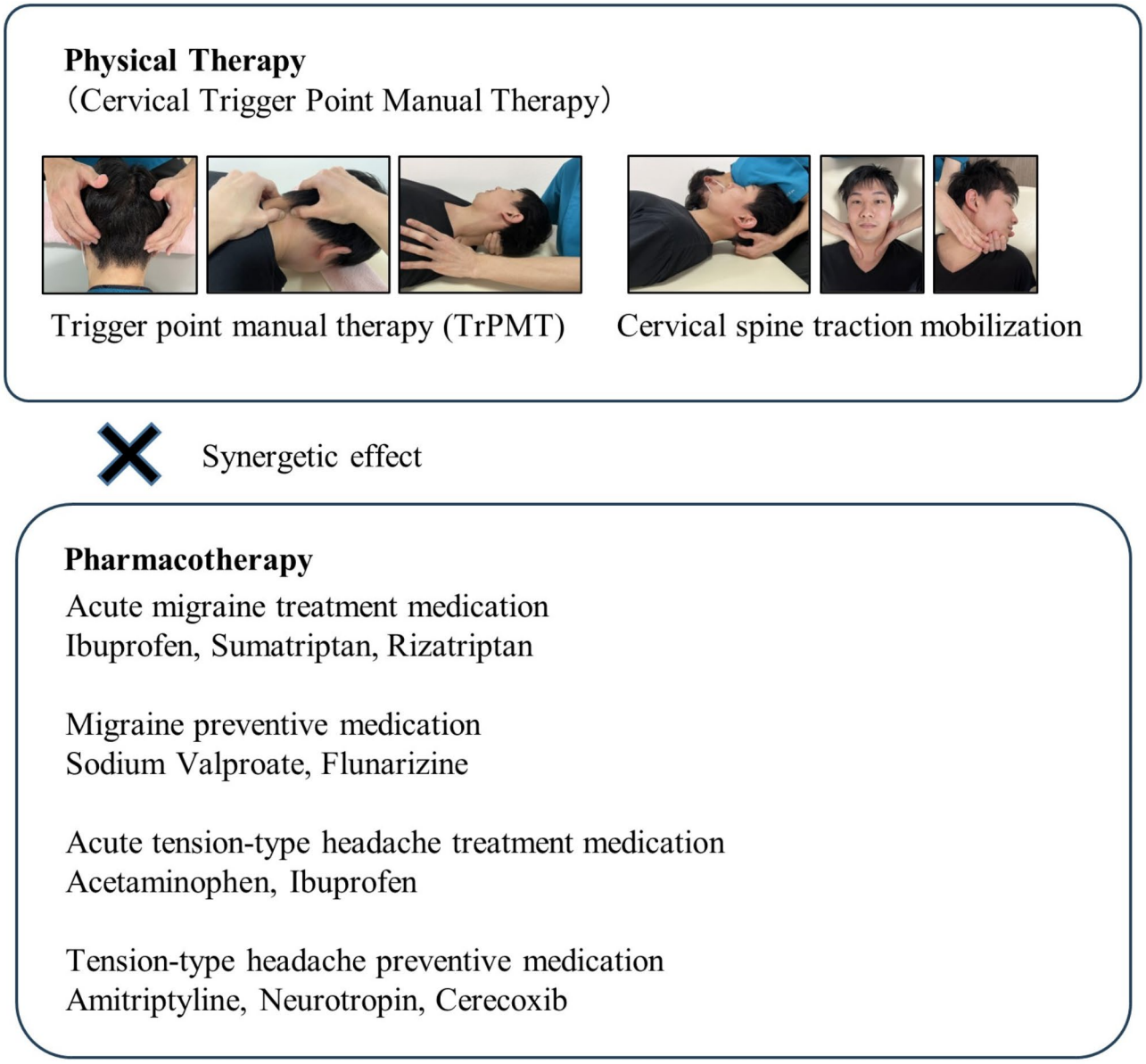

Fig. 2 Integrated physical therapy. The figure illustrates the concept of integrated physical therapy, which combines various physical therapy techniques and methodologies into a cohesive treatment plan. This approach includes a blend of manual therapies, exercise, different modalities, and patient education. The integration of different strategies results in a tailored therapy program designed to address the multifaceted needs of the patient for optimal rehabilitation outcomes

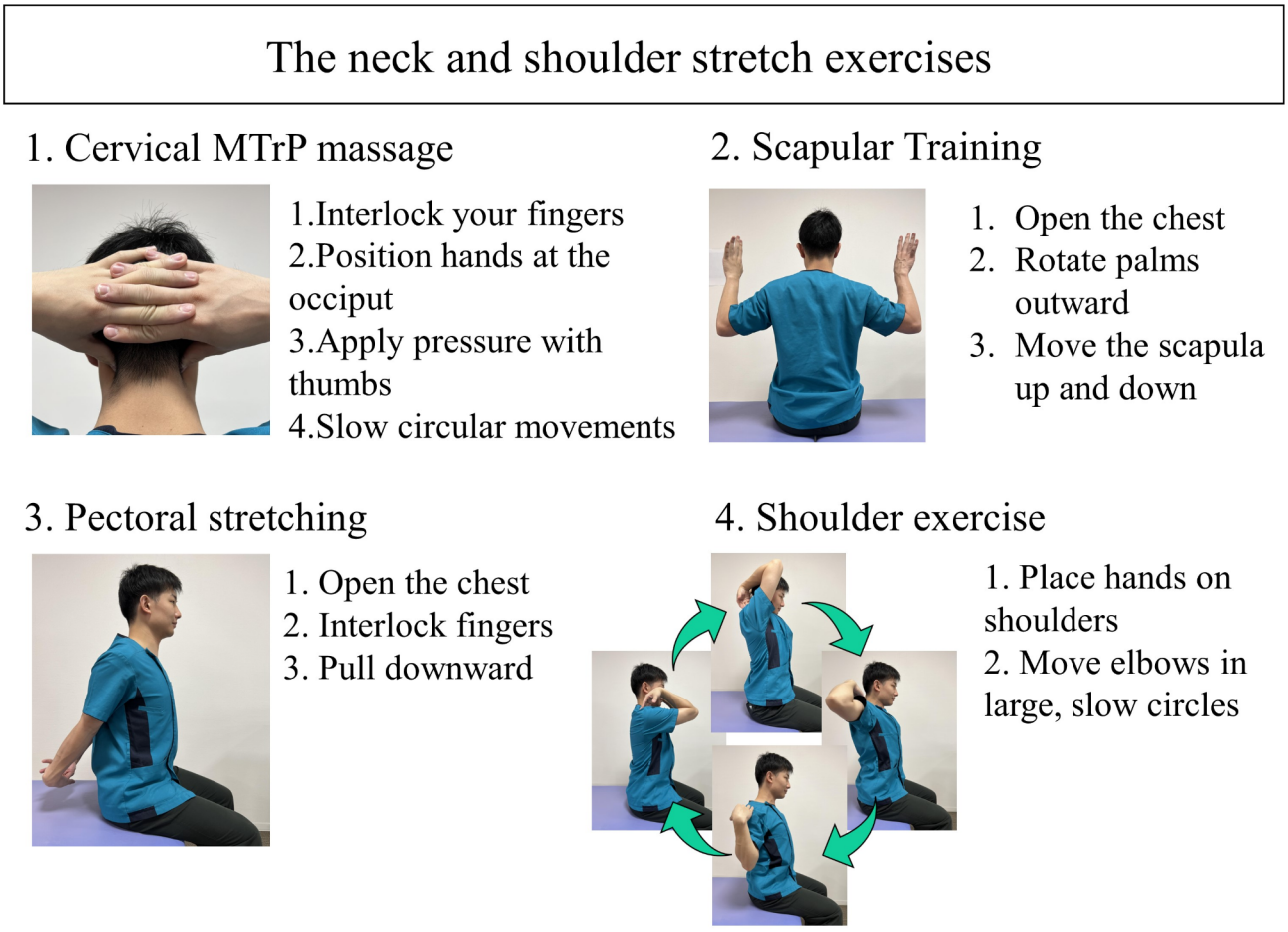

Fig. 3 Neck and shoulder stretch exercises. The figure illustrates the neck and shoulder stretch exercises, which include cervical MTrP massage, scapular training, pectoral stretching and shouder exercise. These exercises are designed to alleviate muscle tension, improve flexibility, and reduce the frequency and intensity of headaches

weekly physical therapy session. The integrated physical therapy persisted until the treatment goals mentioned above were achieved.

Pharmacotherapy

Pharmacotherapy was tailored to each patient based on our assessments and the effectiveness of physical therapy. For acute-phase treatment, acetaminophen (200–400 mg) or ibuprofen (200–400 mg) was administered for both TTH and migraine. Treatment specifically targeting migraine included sumatriptan nasal spray or a 5 mg rizatriptan tablet. Patients who are considered for preventive treatment remain adversely affected on at least 2 days per months [33]. Patients with migraine having 8–14 and 15–23 headache days per month had similar and substantial disease burden, impact on work productivity, and risk of moderate or severe symptoms of depression and anxiety [34]. In this study, prophylactic medications were prescribed only when headaches were frequent (typically more than 8 days per month) and severe enough to impact the patient's daily function or QOL, such as causing school absenteeism. To minimize adverse effects, prophylactic medications were initiated at an appropriate dose and adjusted or discontinued based on the response to the integrated physical therapy. A small dose of amitriptyline (2.5 mg before bedtime) was used for both TTH and migraine. In Japan, valproic acid and lomerizine hydrochloride are the only prophylactic medications approved for migraine under the national universal insurance system. We administered valproic acid (400 ~ 800 mg/day) across all age groups and lomerizine hydrochloride (10 mg/ day) for adolescents over 15 years. Additionally, we occasionally prescribed Neurotropin (Nippon Zoki Pharmaceutical Co., Ltd) (4–8 units/day), which a nonprotein extract obtained from inflamed rabbit skin inoculated with vaccinia virus, and cerecoxib (200 mg/ day), a non-steroid anti-inflammatory drug, to alleviate neck pain. For patients with TTH, the prophylactic medications were concluded within the duration of physical therapy. For migraine patients, the prophylactic medications were continued after the completion of physical therapy to maintain headache frequency at

three or fewer episodes per month. For most prophylactic medications, clinical experience suggests that pausing can be considered when treatment has been successful for 6–12 months [33]. The purpose of pausing is to ascertain whether prophylactic medications can be stopped, which minimizes the risk of unnecessary drug exposure [31]. In this study, once the headache completely disappeared for a few months, we have attempted a drug withdrawal to observe for headache recurrence.

Statistics

Statistical analyses for this study were performed using IBM SPSS Statistics Version 24 (International Business Machines Corporation). We explored differences in patient characteristics and treatment effects among 4 headache-type groups: FETTH, CTTH, EM, and CM. The Shapiro-Wilk test was used to evaluate the normality of the data distribution for each group. Given that the patient data were not normally distributed across headache types, the Kruskal-Wallis test was applied for intergroup comparisons. This was followed by post-hoc analysis using the Mann-Whitney U test. To account for multiple comparisons, the Bonferroni correction was applied to adjust the significance levels. In addition, the Friedman test was applied to evaluate the treatment effect at three different time points (pre-treatment, 1 month post-treatment, and post-treatment). A post-hoc analysis with Wilcoxon's signed-rank test was then performed. A significance level of 5% was set for all analyses.

Results

Patients (Fig. 4)

We initially recruited a total of 209 consecutive patients. We excluded 5 patients because of premature termination of treatment, and 4 patients because of infrequent episodic TTH, resulting in a primary cohort of 200 patients. Subsequently, we excluded 39 patients with OH and POTS. Ultimately, 161 patients were eligible for inclusion in the study analysis. Of these, 106 patients (65.8%) were diagnosed with TTH: 70 (66.0%) with FETTH, and 36 (34.0%) with CTTH. The remaining 55 patients (34.2%) had migraine: 43 patients (78.2%) with EM, and 12 patients (21.8%) with CM.

Participant characteristics according to primary headache types (FETTH/ CTTH/ EM/ CM)

Table 1 presents the basic characteristics of the study participants. The participants were classed into 4 groups according to headache type: FETTH, CTTH, EM, and CM. Comparative analyses were conducted among these groups. No statistically significant differences were observed across the groups in terms of age, school grade, gender, Body Mass Index (BMI), number of days absent from school, duration of illness, history of over-the-counter (OTC) medication usage, frequency of visits to various medical facilities, or prevalence of lost physiological cervical lordosis. The average duration of illness was approximately one-year across all headache types. The participants commonly sought care at multiple medical facilities and frequently used OTC medications. 45.3% of patients reported school absenteeism attributed to headaches. 70.8% of patients presented with loss of physiological cervical lordosis.

Table 2 delineates the outcomes of multifaceted assessments comparing the 4 primary headache types (FETTH, CTTH, EM, CM). Notable differences were evident in 7 parameters: headache frequency, PCS scores (encompassing rumination, helplessness, magnification, and total scores), HADS depression scores, HIT-6 scores, and EQ-5D-5 L scores. A marked increase in headache frequency was observed in the CTTH and CM groups when contrasted with the FETTH and EM groups. PCS rumination scores were substantially higher in the EM group relative to the FETTH group. HADS depression scores were significantly elevated in the CTTH and CM groups compared with the FETTH group. HIT-6 scores, indicative of headache impact, were significantly elevated in the CTTH, EM, and CM groups in comparison with the FETTH group. QOL measured by the EQ-5D-5 L was notably lower in the CTTH group compared with both the FETTH and EM groups.

Effectiveness of integrated physical therapy

Table 3 compares the effectiveness of integrated physical therapy for the 4 headache types (FETTH, CTTH, EM and CM) at 3 assessment points: pre-treatment, 1-month post- treatment, and at the final assessment. Significant post-treatment improvements were observed across all headache types. In the FETTH group, we observed a significant improvement in headache frequency ($p=0.000$), intensity ($p=0.000$), PCS rumination score ($p=0.000$), HADS anxiety score ($P=0.000$), and HIT-6 scores ($p=0.000$) from pre-treatment to 1-month post-treatment. At the final assessment, we observed significant improvements in headache frequency ($p=0.000$), intensity ($p=0.000$), cervical flexion range of motion ($p=0.003$), PCS score (rumination, helplessness, magnification, total) ($p=0.000$), HADS score (anxiety, depression) ($p=0.000$), HIT-6 score ($p=0.000$), and EQ-5D-5 L score ($p=0.000$). In the CTTH group, there were significant improvement in headache frequency ($p=0.000$), intensity ($p=0.000$), and HIT-6 score ($p=0.000$) from pre-treatment to 1-month post-treatment. At the final assessment, significant improvements were found in terms of headache frequency ($p=0.000$), intensity ($p=0.000$), cervical extension ($p=0.046$), right lateral flexion ($p=0.009$), left lateral flexion range of motion ($p=0.021$), PCS score (rumination, helplessness,

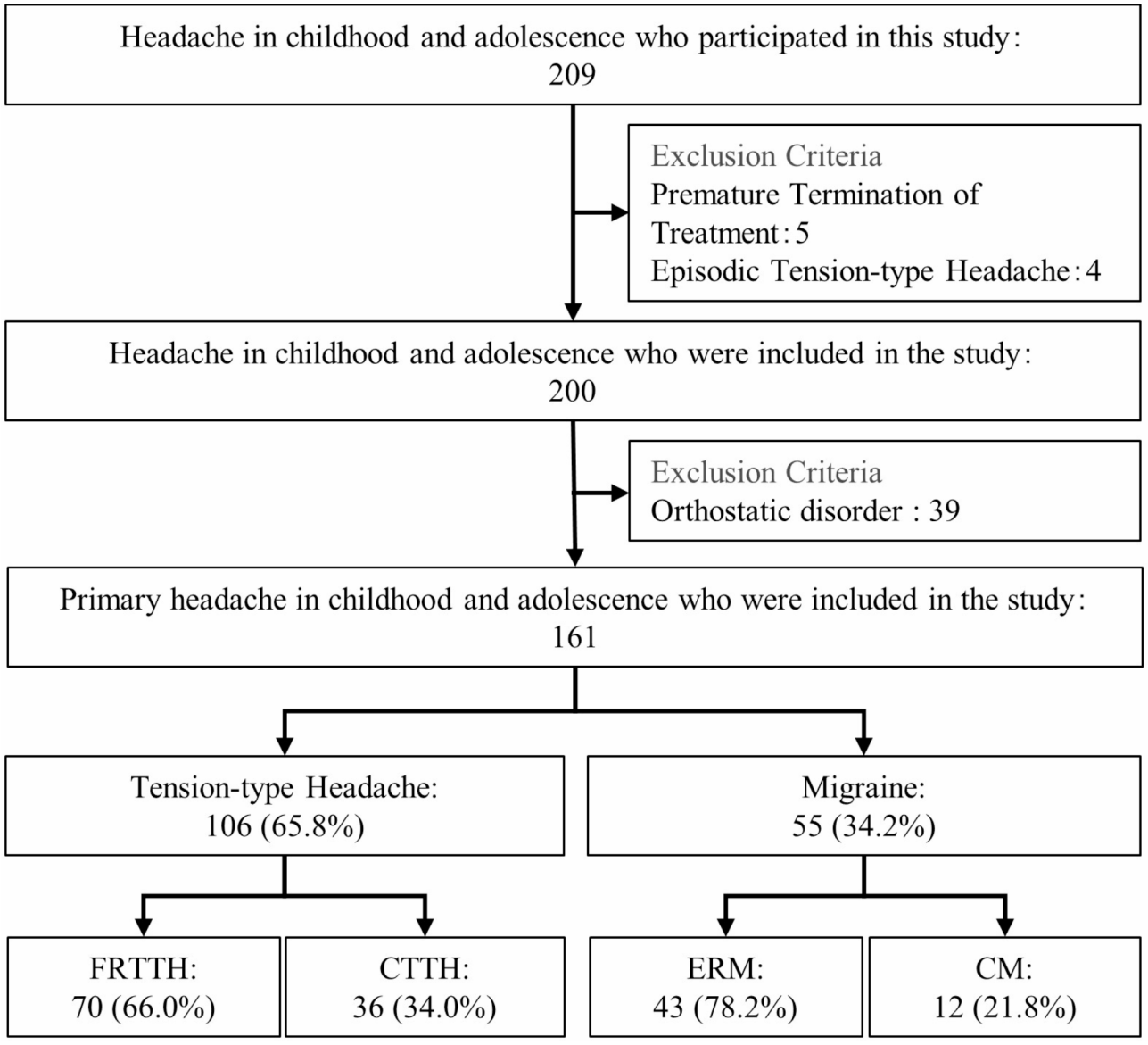

Fig. 4 Flow chart of the study process based on International Classification of Headache, 3rd ed (ICHD-3). TTH: Tension-type headache; FETH: Frequent episodic tension-type headache; CTTH: Chronic tension-type headache; EM: Episodic migraine; CM: Chronic migraine

magnification, total) (p=0.000), HADS score (anxiety, depression) (p=0.004), HIT-6 score (p=0.000), and EQ-5D-5 L score (p=0.000). In the EM group, significant improvements in headache intensity (p=0.000) and right cervical lateral flexion range of motion (p=0.004) were observed from pre-treatment period to 1-month post-treatment. At the final assessment, significant improvements were found in headache frequency (p=0.000), intensity (p=0.000), right cervical lateral flexion range of motion (p=0.004), PCS score (rumination (p=0.000), helplessness (p=0.000), magnification (p=0.001), total (p=0.000)), HIT-6 score (p=0.000), and EQ-5D-5 L score (p=0.001). In the CM group, significant improvement in weekly minimum headache intensity (p=0.001) and total PCS score (p=0.003) were found from the pre-treatment to 1-month post-treatment. At the final assessment, significant improvements were found in headache frequency (p=0.000), intensity (p=0.001), PCS score (rumination (p=0.011), helplessness (p=0.001), total (p=0.003)), HIT-6 score (p=0.000), and EQ-5D-5 L score (p=0.029) Figure 5 illustrates these results.

Figure 6A shows the frequency of integrated physical therapy sessions (once-week sessions) required to achieve the treatment goals (reduction in headache frequency to less than twice a week, HIT-6 score below 50, and the ability to attend school daily). Figure 6B shows the percentage of headache patients requiring 5 or more integrated physical therapy sessions to achieve the

Table 1 The basic characteristics of the participants in this study

Variable	Total (*n* = 161) Median (IQRs)	TTH (*n* = 106) Median (IQRs)		Migraine (*n* = 55) Median (IQRs)		*P*- value
		FETTH (*n* = 70)	CTTH (*n* = 36)	EM (*n* = 43)	CM (*n* = 12)	
Age, y	15 (13–16)	15 (12.8–17)	15 (13-16.3)	13 (12–16)	16 (14.5–16)	*P* = 0.053
Grade of school, n(%)						
Elementary school students	28 (17.4)	12 (17.1)	4 (11.1)	12 (27.9)	1 (8.3)	*P* = 0.413
Junior high school students	69 (42.9)	29 (41.4)	17 (47.2)	18 (41.9)	5 (41.7)	*P* = 0.413
High school students	64 (39.8)	29 (41.4)	15 (41.7)	13 (30.2)	6 (50)	*P* = 0.413
Sex, **Female**, n(%)	93 (57.8)	39 (55.7)	23 (63.9)	25 (58.1)	6 (50)	*P* = 0.709
BMI, kg/cm^2	19.3 (17.4–20.5)	19.3 (17.5–20.4)	19.3 (17.3–20.7)	19.1 (16.7–20.4)	20.4 (19.0-21.5)	*P* = 0.377
School absenteeism, n(%)	73 (45.3)	34 (48.6)	15 (41.7)	18 (41.9)	6 (50)	*P* = 0.844
Duration of disease, days	365 (60-1095)	365 (14-1004)	365 (60-1095)	365 (249–1095)	365 (365–1460)	*P* = 0.162
Experience with OTC medication use, n(%)	52 (32.3)	22 (31.4)	17 (47.2)	11 (25.6)	2 (16.7)	*P* = 0.098
Visits to multiple medical facilities, n(%)	50 (31.1)	21 (30)	11 (30.6)	15 (34.9)	3 (25)	*P* = 0.868
Loss of physiological cervical lordosis, n(%)	114 (70.8)	45 (64.3)	25 (69.4)	34 (79.1)	9 (75)	*P* = 0.143

P-value obtained from statistical Kruskal-Wallis test; TTH: Tension-type headache; FETTH: Frequent episodic tension-type headache; CTTH: Chronic tension-type headache; EM: Episodic migraine; CM: Chronic migraine; IQRs: Interquartile Ranges; OTC: over-the-counter

Table 2 Comparison of multifaceted assessments of the four primary headache types

Variable	Total (*n* = 161) Median (IQRs)	TTH (*n* = 106) Median (IQRs)		Migraine (*n* = 55) Median (IQRs)		*P*- value
		FETTH (*n* = 70)	CTTH (*n* = 36)	EM (*n* = 43)	CM (*n* = 12)	
Headache frequency, day/once week	4 (3–7)	3 (2–5)	7 (5–7)*†	3 (1–6)	7 (6–7)*†	*P* = 0.000
Headache intensity, VAS, mm						
Weekly average	51 (34–64)	49 (34–62)	52 (33–68)	51 (33–65)	59 (36–70)	*P* = 0.771
Weekly maximum	77 (64–86)	76 (61–85)	77 (66–85)	78 (50–92)	79 (67–89)	*P* = 0.914
Weekly minimum	3 (0–17)	4 (0–15)	4 (0–17)	0 (0–11)	23 (0–43)	*P* = 0.093
The range of motion of the cervical spine, °						
Flexion	56 (49–68)	56 (48–66)	56 (46–64)	56 (51–73)	53 (46–73)	*P* = 0.368
Extension	67 (58–77)	66 (59–77)	66 (53–73)	69 (58–83)	62 (56–74)	*P* = 0.233
Right rotation	65 (59–74)	64 (58–74)	64 (58–71)	67 (62–72)	63 (53–77)	*P* = 0.750
Left rotation	64 (59–70)	64 (60–71)	65 (55–69)	64 (60–70)	61 (57–68)	*P* = 0.782
Right lateral flexion	36 (32–42)	38 (32–46)	35 (32–40)	35 (31–39)	34 (27–41)	*P* = 0.087
Left lateral flexion	37 (32–44)	38 (32–45)	37 (33–41)	36 (31–44)	37 (32–44)	*P* = 0.523
PCS, point						
Rumination	13 (9–16)	12 (9–15)	12 (9–16)	15 (10–18)*	15 (9–17)	*P* = 0.017
Helplessness	8 (4–12)	6 (3–11)	7 (4–12)†	11 (7–14)*	9 (7–12)*	*P* = 0.003
Magnification	4 (2–6)	4 (1–5)	5 (2–8)*	4 (3–7)*	3 (1–6)	*P* = 0.045
Total	24 (15–32)	21 (12–29)	25 (18–33)*	28 (17–36)*	25 (18–37)	*P* = 0.008
HADS, point						
Anxiety	7 (3–9)	7 (3–8)	7 (2–12)	6 (4–11)	6 (5–12)	*P* = 0.483
Depression	5 (2–8)	5 (2–7)	7 (3–8)*	5 (2–7)	7 (5–9)*	*P* = 0.034
HIT-6, point	63 (59–66)	60 (57–65)	64 (60–66)*	63 (59–68)*	66 (61–68)*	*P* = 0.030
EQ-5D-5 L, point	0.82 (0.73–0.90)	0.90 (0.79–0.94)	0.75 (0.63–0.84)*†	0.84 (0.73–0.91)	0.78 (0.70–0.90)	*P* = 0.003

P-value obtained from statistical Kruskal-Wallis test; TTH: Tension-type headache; FETTH: Frequent episodic tension-type headache; CTTH: Chronic tension-type headache; EM: Episodic migraine; CM: Chronic migraine; IQRs: Interquartile Ranges; PCS: pain catastrophizing scale; HADS: hospital anxiety and depression scale; HIT-6: headache impact test 6 score; EQ-5D-5 L: EuroQol 5 dimension 5-level questionnaire *: There was a significant difference in FETTH; †: There was a significant difference in EM

treatment goals. Across the study cohort, the treatment duration averaged 5 sessions (±3.5), ranging from a minimum of 2 to a maximum of 24 sessions. Patients with FETTH underwent an average of 4.7 sessions (±1.8), with the number of sessions required ranging from 2 to 10, and 44.3% (31 out of 70 patients) necessitated more than 5 sessions to achieve treatment goals. In the CTTH category, the average increased to 6.6 (±3.0) sessions, with the number of sessions needed ranging from 3 to 14 sessions, and 69.4% (25 out of 36) required more than 5 sessions. EM patients underwent an average of 5.6 (±4.3) sessions, with the number of sessions ranging from 2 to 24

Table 3 Comparison of the effectiveness of integrative physical therapy at three different time points (first, one month after treatment, and at the last of treatment)

Variable	FETTH (70) Median (IQRs)			*P*- value	CTTH (36) Median (IQRs)			*P*- value
	First	One month after	Last		First	One month after	Last	
Headache frequency, day/once week	3 (2–5)	2 (0–3)*	0 (0–1)*†	*P* = 0.000	7 (5–7)	3 (1–7)*	1 (0–2)*†	*P* = 0.000
Headache intensity, VAS, mm								
Weekly average	49 (34–62)	20 (12–54)*	0 (0–13)*†	*P* = 0.000	52 (33–68)	24 (7–49)*	5 (0–23)*	*P* = 0.000
Weekly maximum	76 (61–85)	49 (17–80)*	0 (0–41)*†	*P* = 0.000	77 (66–85)	52 (21–78)*	12 (0–40)*†	*P* = 0.000
Weekly minimum	4 (0–15)	0 (0–11)	0 (0–0)*†	*P* = 0.000	4 (0–17)	0 (0–11)	0 (0–0)*	*P* = 0.000
The range of motion of the cervical spine, °								
Flexion	56 (48–66)	55 (47–59)	63 (52–70)*†	*P* = 0.003	56 (46–64)	60 (51–72)	59 (49–72)	*P* = 0.548
Extension	66 (59–77)	70 (65–84)	71 (64–81)	*P* = 0.073	66 (53–73)	75 (62–81)	71 (61–83)*	*P* = 0.046
Right rotation	64 (58–74)	68 (58–74)	69 (62–75)	*P* = 0.313	64 (58–71)	64 (55–74)	71 (60–76)	*P* = 0.333
Left rotation	64 (60–71)	65 (59–70)	69 (64–75)	*P* = 0.068	65 (55–69)	62 (56–71)	68 (60–75)	*P* = 0.236
Right lateral flexion	38 (32–46)	39 (32–46)	40 (32–48)	*P* = 0.608	35 (32–40)	42 (33–45)	40 (36–46)*	*P* = 0.009
Left lateral flexion	38 (32–45)	35 (34–43)	40 (35–49)	*P* = 0.197	37 (33–41)	40 (34–44)	42 (35–48)*	*P* = 0.021
PCS, point								
Rumination	12 (9–15)	8 (5–12)*	5 (1–9)*	*P* = 0.000	12 (9–16)	10 (5–14)	5 (0–7)*	*P* = 0.000
Helplessness	6 (3–11)	4 (1–7)	2 (0–5)*	*P* = 0.000	7 (4–12)	5 (2–7)	2 (0–5)*	*P* = 0.000
Magnification	4 (1–5)	2 (1–4)	1 (0–3)*	*P* = 0.000	5 (2–8)	4 (1–6)	0 (0–3)*†	*P* = 0.000
Total	21 (12–29)	14 (8–22)	10 (1–16)*	*P* = 0.000	25 (18–33)	17 (9–25)	6 (1–15)*†	*P* = 0.000
HADS, point								
Anxiety	7 (3–8)	3 (1–7)*	3 (1–6)*	*P* = 0.000	7 (2–12)	7 (3–11)	3 (1–5)*†	*P* = 0.004
Depression	5 (2–7)	4 (2–7)	2 (1–4)*	*P* = 0.000	7 (3–8)	4 (3–7)	2 (1–6)*	*P* = 0.004
HIT-6, point	60 (57–65)	55 (48–59)*	47 (42–51)*†	*P* = 0.000	64 (60–66)	57 (51–62)*	46 (40–53)*†	*P* = 0.000
EQ-5D-5 L, point	0.90 (0.79–0.94)	0.90 (0.82–0.94)	0.94*† (0.90–0.94)	*P* = 0.000	0.75 (0.63–0.84)	0.82 (0.77–0.90)	0.94*† (0.90–0.94)	*P* = 0.000
Variable	**EM (43) Median (IQRs)**			***P*- value**	**CM (12) Median (IQRs)**			***P*- value**
	First	**One month after**	**Last**		**First**	**One month after**	**Last**	
Headache frequency, day/once week	3 (1–6)	2 (0–5)	0 (0–2)*†	*P* = 0.000	7 (6–7)	5 (2–7)	1 (0–2)*	*P* = 0.000
Headache intensity, VAS, mm								
Weekly average	51 (33–65)	37 (18–53)	0 (0–22)*†	*P* = 0.000	59 (36–70)	34 (27–45)	12 (0–20)*	*P* = 0.000
Weekly maximum	78 (50–92)	73 (60–80)*	0 (0–50)*†	*P* = 0.000	79 (67–89)	70 (49–85)	33 (0–51)*†	*P* = 0.001
Weekly minimum	0 (0–11)	0 (0–0)*	0 (0–0)*	*P* = 0.000	23 (0–43)	0 (0–1)*	0 (0–0)*	*P* = 0.001
The range of motion of the cervical spine, °								
Flexion	56 (51–73)	60 (52–75)	55 (46–62)	*P* = 0.075	53 (46–73)	63 (52–68)	59 (51–70)	*P* = 0.495
Extension	69 (58–83)	70 (58–74)	71 (62–82)	*P* = 0.904	62 (56–74)	73 (69–81)	74 (61–84)	*P* = 0.393
Right rotation	67 (62–72)	68 (61–79)	70 (63–78)	*P* = 0.418	63 (53–77)	74 (67–80)	73 (59–75)	*P* = 0.276
Left rotation	64 (60–70)	64 (59–75)	67 (61–74)	*P* = 0.430	61 (57–68)	65 (62–75)	70 (63–75)	*P* = 0.387
Right lateral flexion	35 (31–39)	41 (39–45)*	38 (34–41)	*P* = 0.004	34 (27–41)	45 (39–51)	36 (33–45)	*P* = 0.050
Left lateral flexion	36 (31–44)	42 (39–44)	38 (35–42)	*P* = 0.059	37 (32–44)	46 (40–52)	38 (34–44)	*P* = 0.074
PCS, point								
Rumination	15 (10–18)	13 (9–15)	7 (2–14)*	*P* = 0.000	15 (9–17)	10 (8–14)	7 (2–12)*	*P* = 0.011
Helplessness	11 (7–14)	6 (3–13)	2 (0–8)*†	*P* = 0.000	9 (7–12)	6 (3–9)	2 (1–6)*	*P* = 0.001
Magnification	4 (3–7)	4 (2–7)	2 (0–5)*†	*P* = 0.001	3 (1–6)	1 (0–4)	3 (0–5)	*P* = 0.229
Total	28 (17–36)	24 (16–36)	13 (4–27)*†	*P* = 0.000	25 (18–37)	19 (10–25)*	13 (2–21)*	*P* = 0.003
HADS, point								
Anxiety	6 (4–11)	7 (5–9)	4 (1–8)	*P* = 0.057	6 (5–12)	6 (4–7)	5 (3–6)	*P* = 0.171
Depression	5 (2–7)	5 (3–8)	3 (1–5)	*P* = 0.062	7 (5–9)	4 (3–8)	5 (3–7)	*P* = 0.083

Table 3 (continued)

Variable	EM (43) Median (IQRs)			*P*- value	CM (12) Median (IQRs)			*P*- value
	First	One month after	Last		First	One month after	Last	
HIT-6, point	63 (59–68)	60 (50–64)	50 (46–56)*†	*P* = 0.000	66 (61–68)	60 (56–63)	49 (42–54)*	*P* = 0.000
EQ-5D-5 L, point	0.84 (0.73–0.91)	0.90 (0.78–0.94)	0.94* (0.90–0.94)	*P* = 0.001	0.78 (0.70–0.90)	0.82 (0.75–0.94)	0.92* (0.90–0.94)	*P* = 0.029

P-value obtained from statistical Friedman test; TTH: tension-type headache; FETTH: frequent episodic tension-type headache; CTTH: chronic tension-type headache; EM: Episodic migraine; CM: chronic migraine; IQRs: Interquartile Ranges; VAS: Visual analogue scale; PCS: Pain catastrophizing scale; HADS: Hospital anxiety and depression scale; HIT-6: Headache impact test-6; EQ-5D-5 L: EuroQol 5 dimension 5 levels; *: significant difference for FETTH; †: significant difference for EM

sessions, and 32.6% (14 out of 43) necessitated more than 5 sessions. A 12-year-old boy with substantially physical frailty in this group required 24 sessions (24 weeks), as conditioning his body required time before observing a reduction in headache frequency. CM patients had the longest treatment duration, with an average of 10.0 (±5.9) sessions, and 91.7% (11 out of 12) required 5 or more sessions, spanning from 3 to 20 sessions.

Discussion

The effectiveness of physical therapy for treating TTH and migraine in adults has been well documented and systematically reviewed [25–30]. Jung et al. reviewed 20 reports of randomized controlled trials investigating the effectiveness of physical therapy for TTH, and reported that a combination of passive physical therapy techniques with exercise and/or transcutaneous electrical stimulation appeared to be the most effective for reducing headache intensity and frequency in the short term [29]. Onan et al. reviewed randomized controlled trials investigating the effectiveness of a physical therapy intervention for CM [30]. Among these, only the report by Cerritelli et al. used a manual form of physical therapy. The authors reported a 50% reduction in the frequency of migraines after an 8-week interventions [35].

TTH and migraine have distinct pathophysiological mechanisms. However, it is important to highlight that both conditions frequently coexist with high prevalence of neck pain [7] and associated MTrPs in the cervical region [9, 13]. The pathophysiological link between neck pain and both types of headaches has been well-documented, indicating that cervical MTrPs can contribute significantly to the headache symptoms in both TTH and migraine [10]. In our study, we recruited the pediatric TTH and migraine patients with cervical MTrPs. The role of cervical MTrPs in exacerbating headache symptoms through referred pain mechanisms and their impact on the cervical musculature supports the rationale for utilizing a similar physiotherapeutic approach targeting these trigger points. Manual therapy techniques, including myofascial release and ischemic compression, aim to alleviate the hyperirritable spots in the cervical muscles, thereby reducing the overall headache burden [12–15].

In our study, the assessment of cervical alignment abnormalities was performed using simple radiographs of the cervical spine. These radiographs allowed us to evaluate the loss of physiological cervical lordosis and the presence of lateral flexion. Specifically, lateral view radiographs were used to assess cervical spine curvature, and deviations from the normal lordosis curve were recorded. In addition, anteroposterior view x-rays helped to identify lateral deviation and scoliosis of the cervical spine. Assessment of muscle weakness in the trunk and extremities was based primarily on clinical observations during patient examinations. During the examination, the patient's posture was carefully observed and signs of muscle weakness were noted, such as difficulty maintaining an upright posture, slender build, and prominent scapular winging. These observational findings, combined with the patient's history and reported symptoms, provided a comprehensive understanding of muscle strength status. The integration of these assessment methods provided a comprehensive evaluation of the common physical characteristics. We observed the significant improvement of the range of motion of the cervical spine after the integrated physical therapy. Any deviations from the normal alignment of the mass of the head would result in a biomechanical imbalance of the cervical spine and an increase in muscular energy expenditure, and bringing a variety of disorders and complications [36]. The manual correction of cervical spine malalignment by cervical spine mobilization using in this study might attributed the relief of headache.

The notable characteristics of this study participants were the prolonged duration of headache approximately one-year, high percentage of history to multiple healthcare facilities and high percentage of history of OTC medication use. These patients were at risk of MOH. A significant proportion of patients reported school absenteeism attributed to headache, underscoring the substantial impact of headaches on their educational engagement. Furthermore, our findings indicated that chronic type of headache, particularly CTTH and CM, are correlated with increased headache frequency and more pronounced psychological distress, as evidenced by elevated PCS rumination and HADS depression scores.

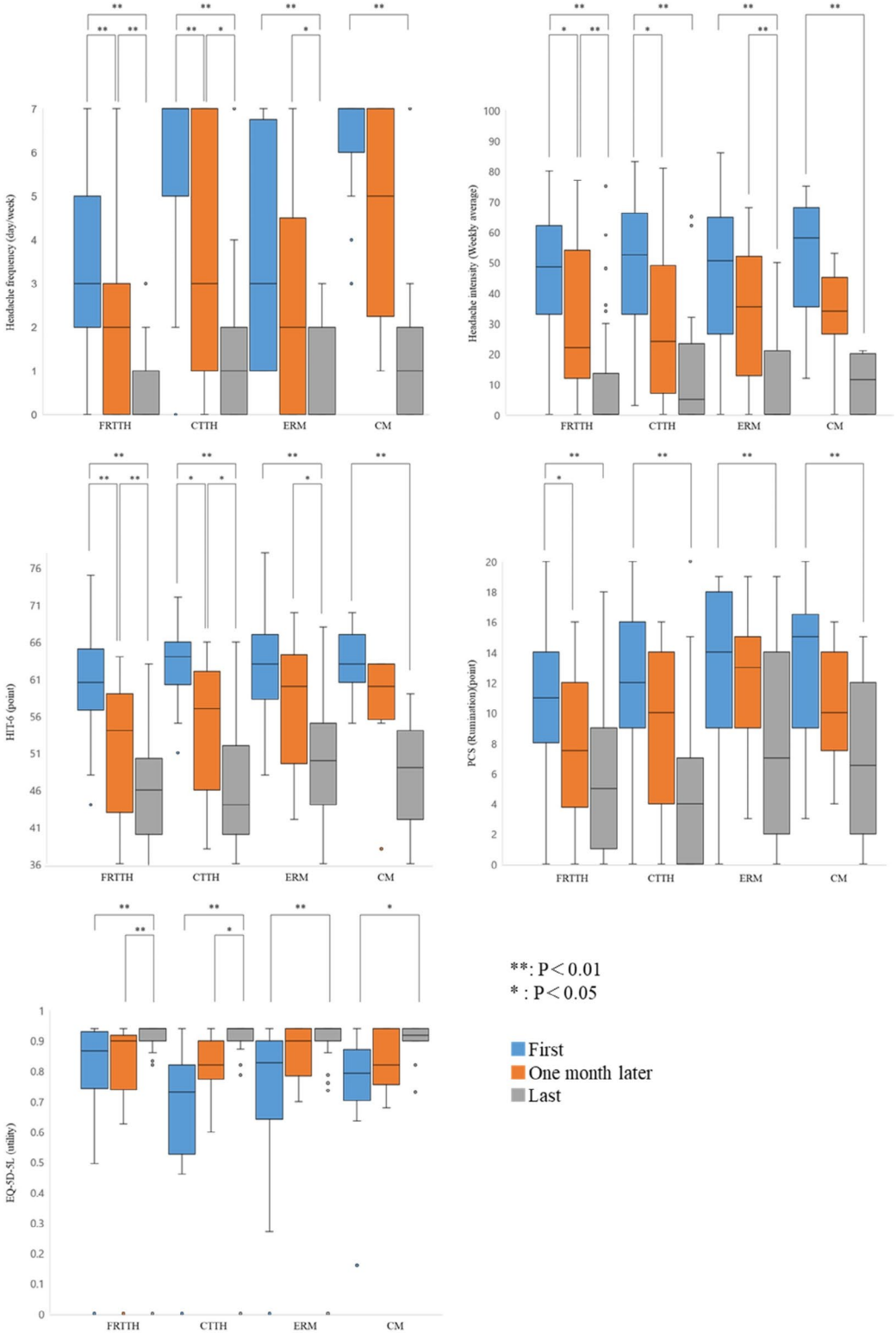

Fig. 5 Comparison of the effectiveness of integrative physical therapy at 3 different time points (pre-treatment, 1 month after treatment, and at the last treatment). We used the Kruskal-Wallis test. For multiple comparisons, a Bonferroni correction was applied to adjust the significance level. In addition, the Friedman test was applied to evaluate the treatment effect at 3 different time points. A post-hoc analysis with Wilcoxon's signed-rank test was then performed. TTH: Tension-type headache; FETTH: Frequent episodic tension-type headache; CTTH: Chronic tension-type headache; EM: Epsodic migraine; CM: Chronic migraine; *$p < 0.05$; **$p < 0.01$

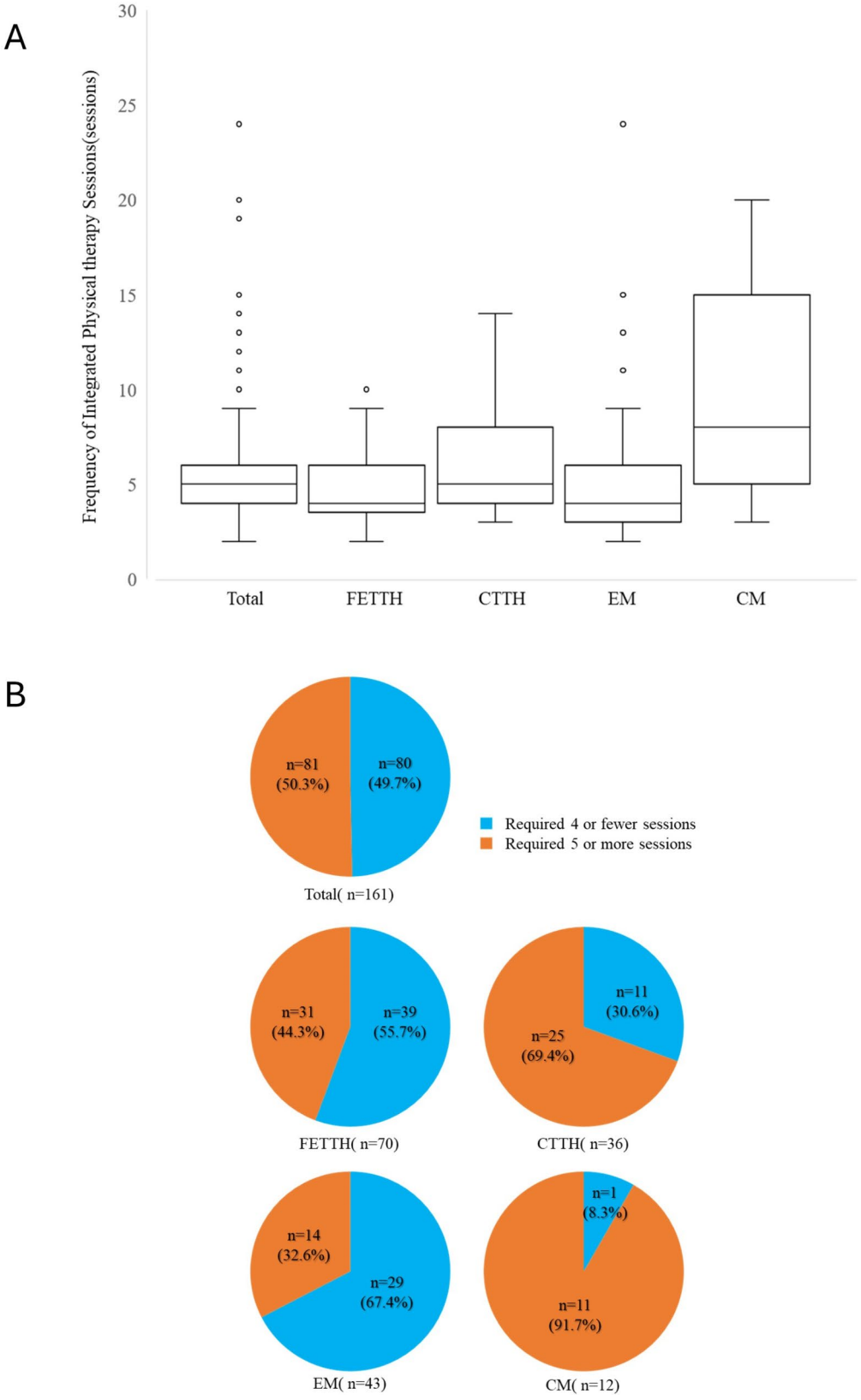

Fig. 6 Frequency of integrated physical therapy sessions. **A**; The Kruskal-Wallis test; FETTH: Frequent episodic tension-type headache; CTTH: Chronic tension-type headache; EM: Episodic migraine; CM: Chronic migraine. **B**; Percentage of headache patients requiring 5 or more integrated physical therapy sessions to improve headache; FETTH: Frequent episodic tension-type headache; CTTH: Chronic tension-type headache; EM: Episodic migraine; CM: Chronic migraine

The escalated HIT-6 score in the CTTH, EM, and CM groups suggested a more profound impact on ADL relative to FETTH. Specifically, the reduced QOL in CTTH patients underscores the extensive burden that chronic headaches place on individual well-being. Starting from the consideration that children and adolescents with headache show greater indices of psychopathology [37, 38] and show higher risk of developing psychological disorders in adulthood than healthy controls [39], different psychotherapeutic approaches are sometimes provided in clinical practice [40]. Relaxation and cognitive-behavioral techniques have been found to reduce the intensity and frequency of headache in children and adolescents [41, 42]. The integrated physical therapy which was structured multimodally significantly improved a series of questionnaires related to PCS and HADS in this study. It provided relaxation through cervical trigger point manual therapy, the neck and shoulder exercise and outdoor brisk walking as an aerobic exercise. Aerobic exercise has been shown to reduce the burden of migraine and the ability to engage in physical activity because of reduced impact of TTT and neck pain [43]. It also significantly their psychological well-being [43]. Although we could not provide structured cognitive-behavioral therapy by a clinical psychologist, the physician and the physical therapists in our clinic worked closely together, using headache diaries and exercise therapy to guide patients in managing their mindset and improving their lifestyle habits. This collaborative effort aimed to offer an alternative treatment as close as possible to cognitive-behavioral therapy.

The frequency of headaches is commonly assessed in terms of the number of headaches per month and is rarely evaluated on a weekly basis due to fluctuations in headache occurrence. However, we deliberately chose to assess headache frequently on a weekly basis for children and adolescent in this study based on our experience of daily clinical practice. We checked the headache frequency every week, and if the frequency hasn't decreased from the previous week, we made meticulous adjustments to the treatment plan and proceed with the treatment. In detail, we modified the intensity and duration of myofascial release and ischemic compression, the direction and amplitude of cervical mobilization based on the patient's tolerance and response to the previous session. We customized the prescribed cervical and shoulder stretching and strengthening exercises based on the patient's conditions. Additionally, we instructed pediatric patients to perform the neck and shoulder exercise and recommended a 20–30 min outdoor brisk walking for 5 days per week as aerobic exercise. We believe that the weekly assessment and instruction are more conductive to improving pediatric patients' ADL and QOL compared to the typical monthly evaluation and treatment used in adult.

The average treatment duration of the integrated physical therapy was only 5 sessions (weeks). Breakdown by headache type revealed: FETTH patients averaged 4.7 sessions, EM patient averaged 5.6 sessions, CTTH patients averaged 6.6 sessions, and CM patients had the longest duration, averaging 10.0 sessions. There was no statistically significant difference in the treatment duration for the 4 types of headaches. However, when analyzing the treatment duration divided into 5 or more and 4 or fewer sessions, it was found that about 90% of CM and about 70% of CTTH needed 5 or more sessions, which reflected the difficulty in treatment encountered in actual clinical practice. Considering the basic characteristics of this study participants, the observed outcomes were faster and more substantial than the previous reports [25–30].

The present study had a prospective design and we excluded 39 patients with concomitant orthostatic dysregulation disorders, including OH or POTS. Freeman et al. reported the pathophysiology and treatment approaches for POTS, emphasizing the need for individualized management strategies that address the autonomic dysfunction [44]. Similarly, Raj highlights the complexities involved in diagnosing and treating orthostatic dysregulation disorders, noting the significant impact these conditions can have on patients' daily lives and overall health [45]. These studies support our rationale for excluding patients with orthostatic dysregulation disorders to maintain the specificity and integrity of our study's focus on TTH and migraine.

In this study, the broad age range of the sample (6–18 years) encompasses many developmental differences, particularly hormonal factors. The presence or absence of secondary sexual characteristics is directory related to hormonal changes and is a crucial factor. In females, the presence or absence of menstruation and dysmenorrhea can significantly affect the frequency and severity of migraines [46–48]. The average age of menarche is 12.8 years, but this may vary geographically [48]. When we divided the sample into two age groups: childhood to mid-puberty (6–14 years) and late-puberty (15–18 years), and analyzed the effects of integrated physical therapy on TTH and migraines separately in males and females, except for headache frequency in female with TTH, no significant difference were observed in treatment efficacy between the groups for headache frequency, headache intensity, PCS, HADS, HIT-6, and EQ-5D-5 L measure (Supplemantary Table S1-S4). Therefore, we concluded that integrated physical therapy was effective across a broad range of from 6 to 18 years.

The major limitation of this study is the lack of a control group, which is a critical aspect in establishing

the comprehensive effectiveness and specificity of the observed outcomes. This constraint is particularly relevant in the context of real-world data, where the inclusion of a control group could significantly enhance the validity and applicably of our findings. Furthermore, the results of pharmacological treatment were included in our outcome measures, and thus may be responsible for some of the improvement seen.

Conclusion

The present study demonstrates, through multifaceted assessments, the effect of physical therapy integrated with pharmacotherapy for treating TTH and migraine in children and adolescents with cervical MTrP. The immediate efficacy of integrated physical therapy is expected to liberate pediatric TTH and migraine patients from school absenteeism and prevent them from into MOH. The absence of a control group limits the conclusiveness of our findings. Future studies with control groups are needed to fully validate these results and to explore broader treatment approaches for children and adolescents with frequent or chronic primary headaches.

Abbreviations

TTH	Tension-type headache
ADL	Activities of daily living
QOL	Quality of life
MTrP	Myofascial trigger point
MTrPs	Myofascial trigger points
FETTH	Frequent episodic tension-type headache
CTTH	Chronic tension-type headache
EM	Episodic migraine
CM	Chronic migraine
HIT-6	Headache impact test 6 score
VAS	Visual analogue scale
PCS	Pain catastrophizing scale
HADS	Hospital anxiety and depression scale
EQ-5D-5L	EuroQol 5 dimensions 5-level questionnaire
ICHD-3	the third edition of the International Classification of Headache Disorders
OH	Orthostatic hypotension
POTS	Postural orthostatic tachycardia syndrome
BMI	Body Mass Index
OTC	Over-the-counter
MOH	Medication over use headache

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

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Author contributions

KA and NS designed and conceptualized the study. KA and NS acquired the data. All authors analyzed and/or interpreted the data. KA and NS drafted the manuscript. KK and SA revised the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study received approval from the Sakai Neurosurgical Clinical Research Ethics Committee (approval number: SNC2023-01). Comprehensive information regarding the study was provided to all participants and their parents, and informed written consent was duly obtained. The study's protocols adhered to the principals outlined in the Declaration of Helsinki.

Consent for publication

The individual picture in Fig. 1is the first author (KA), and that in Fig. 2 is our clinic's physical therapist. Written consents for publication have been obtained from both of them.

Competing interests

The authors declare no competing interests.

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