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Chronic migraine and chronic tension-type headache are associated with concomitant low back pain: Results of the German Headache Consortium study

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ABSTRACT

The objective of this study was to evaluate the association between low and frequent low back pain and chronic migraine (CM) and chronic tension-type headache (CTTH) in a large, German population-based sample. Headaches were diagnosed according to International Classification of Headache Disorders-2 criteria and categorized according to frequency (episodic 1–14 days/month or chronic ⩽15 days/month) and headache type (migraine or TTH). We defined frequent low back pain as self-reported low back pain on ⩾15 days/month. We calculated odds ratios and 95% confidence intervals (CI) using logistic regression analyses, adjusting for sociodemographic covariates. There were 5605 respondents who reported headache in the previous year, of whom 255 (4.5%) had Chronic Headache. Migraine was diagnosed in 2933 respondents, of whom 182 (6.2%) had CM. TTH was diagnosed in 1253 respondents, of whom 50 (4.0%) had CTTH. Among 9944 respondents, 6030 reported low back pain, of whom 1267 (21.0%) reported frequent low back pain. In adjusted models, the odds of having frequent low back pain were between 2.1 (95% CI 1.7-2.6) and 2.7 (95% CI 2.3-3.2) times higher in all episodic headache subtypes when compared to No Headache. The odds of having frequent low back pain were between 13.7 (95% CI 7.4-25.3) and 18.3 (95% CI 11.9-28.0) times higher in all chronic headache subtypes when compared to No Headache. Low and frequent low back pain was associated with CM and CTTH. Multiple explanations may contribute to the association of headache and back pain, including the notion that the neurobiology of chronic headache, independent of primary headache type, not only involves the trigeminal pain pathway, but is also a part of abnormal general pain processing.

1. Introduction

Chronic pain conditions including headache, low back and neck pain, arthritis, and joint pain are common in both developed and developing countries [68]. Chronic pain conditions affect an individual's well-being, ability to work productively, and ability to build social relationships and maintain an independent lifestyle [11,23,68]. Not surprisingly, chronic pain is associated with increased rates of anxiety and depression [14,24,28,44,68].

Headaches represent a frequently occurring pain condition, and they are among the most common disorders of the nervous system. There has been little recognition of their public-health impact; therefore, the World Health Organization recently launched a global campaign to increase understanding of headache-related burden and improve health care resource allocation for this condition [73]. Chronic headaches, defined broadly as those occurring on ⩾15 days/month, affect about 3–4% of the general population and account for a markedly disproportionate share of the overall headache-related burden and costs [50,65,66,76].

Low back pain is another common health problem, with a lifetime prevalence ranging between 11% and 84% for the general population [70]. Similar to headache, those who develop chronic, disabling low back pain account for a disproportionate share of the burden and costs associated with low back pain [15,27,46].

Chronic headache and chronic back or neck pain are interrelated pain conditions. Although the etiology and pathophysiology of chronic headaches, such as migraine and tension-type, differ, there is growing evidence that central sensitization of the pain matrix is

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an important common pathway of the pathophysiology of all chronic headache [5,51] as well as other chronic pain syndromes, including chronic low back pain [47]. In order to quantify associated burden and effectively optimize treatment paradigms for both conditions, it is important to explore the interplay between them. Therefore, we investigated whether the prevalence of low back pain and frequent low back pain would be higher in a population-based sample of people with chronic migraine and chronic tension-type headache. A population-based dataset offers the most robust assessment of the potential association, because clinic-based datasets often present the most severe spectrum of headache and low back pain and are therefore subject to bias.

2. Methods

2.1. Study design

The German Headache Consortium is a large, population-based cohort study supported by the German Federal Ministry of Education and Research. The study was approved by the Ethics Committee of the University of Duisburg-Essen, Germany. Informed written consent was obtained from all subjects.

The study population comprised a random sample of 18,000 residents of 3 regions in Germany: the city of Essen, a large (585,481 residents) city in the North Rhine-Westphalia region in the western part of Germany; the city of Münster, a middle-sized (272,890 residents) town in the western part of Germany; and the rural area of Sigmaringen (the small central town of Sigmaringen with 16,501 residents and 20 adjacent villages) in southern Germany. Inclusion criteria were: 1) age between 18 and 65 years, and 2) German citizenship, to ensure proper knowledge of the German language.

Fig. 1 illustrates the screening procedure. All study subjects received a questionnaire via postal mail, and a reminder notification was sent 2 weeks later to reduce the number of nonresponders. Individuals who did not respond via mail were called and interviewed over the telephone by trained medical students, using the same questionnaire. Individuals who failed to respond to the mailed questionnaire and were telephoned 8 times with no success were considered nonresponders. Individuals who refused the interview either by postal response or by telephone were also considered nonresponders.

A detailed description and validation of the headache-screening questionnaire has been previously published [26,77]. In summary, the questionnaire was based on diagnosis criteria from the second edition of the International Classification of Headache Disorders (ICHD-2) [31] and contained the following domains: 1) personal data, including socioeconomic status, which was based primarily on education to avoid direct questions about income; 2) medical inquiry, including questions designed to diagnose migraine and tension-type headache by ICHD-2 classification criteria as well as questions to ascertain the number of days associated with the different headache types; 3) 2 questions on low back pain (first, "did you have low back pain in the previous 3 months?" and then, if the answer was yes, respondents were asked to report the average number of days with low back pain during the previous 3 months); 4) the number of days of intake of acute pain and headache/migraine medications per month; and 5) comorbidities and the number of days of intake of any nonheadache or nonpain medications per month.

2.2. Headache classification

Study analyses included several classifications for headache based on ICHD-2 criteria [31] and headache day frequency:

- Diagnosis of headache: Respondents who self-reported headache in the previous year and had either $\geqslant$15 headache days/month (chronic headache; CH) or <15 headache days/month (episodic headache; EH).
- Diagnosis of tension-type headache (TTH): Respondents who self-reported headache in the previous year and who met ICHD-2 criteria for definite or probable TTH and had either $\geqslant$15 headache days/month (chronic tension-type headache; CTTH) or <15 headache days/month (episodic tension-type headache; ETTH).

Additionally, the migraine respondents were classified utilizing 2 approaches. The first identified those with ICHD-2 migraine and included those with coexisting TTH. This subset was established in order to best align with the ICHD-2 hierarchical approach to headache diagnosis and with clinical practice and has been denoted as Migraine throughout this manuscript. In order to best evaluate the potential pathophysiological overlap between migraine and low back pain, an additional subset including those with ICHD-2 migraine but excluding those with coexisting TTH (ie, those who met ICHD-2 criteria for definite or probable TTH) was included; this migraine subset has been denoted as Migraine-II throughout this manuscript:

- Diagnosis of Migraine: Respondents who self-reported headache in the previous year and who met ICHD-2 criteria for migraine or probable migraine, *including those who had definite and probable coexisting TTH*, and had either $\geqslant$15 headache days/month (chronic migraine; CM) or <15 headache days/month (episodic migraine; EM).
- Diagnosis of Migraine-II: Respondents who self-reported headache in the previous year and who met ICHD-2 criteria for migraine or probable migraine, *excluding those who had definite and probable with coexisting TTH*, and had either $\geqslant$15 headache days/month (CM-II) or <15 headache days/month (EM-II).

2.3. Data analysis

Results focus on the baseline cross-sectional analyses. All statistics were analyzed using SPSS Statistics software (IBM, Armonk, NY, USA). Descriptive statistics characterized the respondent population by headache subtype. Logistic regression analyses were used to evaluate associations between low back pain (yes vs no) and headache (CH and EH vs the reference group of No Headache), and separately between migraine (CM and EM vs No Headache; CM-II and EM-II vs No Headache) and TTH (CTTH and ETTH vs No Headache). Model covariates included: age (in years), gender (male vs female), drinking (daily vs not daily alcohol consumption), smoking (vs not smoking), education (high, defined as high school or university, vs low), and body mass index (BMI) ($\geqslant$30 vs 25–30 vs $\leqslant$25). Covariates were determined based on published literature suggesting that chronic and episodic headache disorders differ on a number of variables [14,59] and the assumption that these variables may influence the association between headache and low back pain. The analysis populations for the regression models were defined as those who reported headache status with no missing data for appropriate model covariates. Three models were evaluated:

- Model 1 – univariate analysis between headache status and low back pain;
- Model 2 – multivariate analyses including Model 1 + controlling for age and gender;
- Model 3 – multivariate analyses including Model 2 + controlling for drinking status, smoking status, education level, and BMI.

The same modeling procedure was repeated for *frequent* low back pain. The same covariates were included in these models (Models 1-3 as described above for the low back pain models).

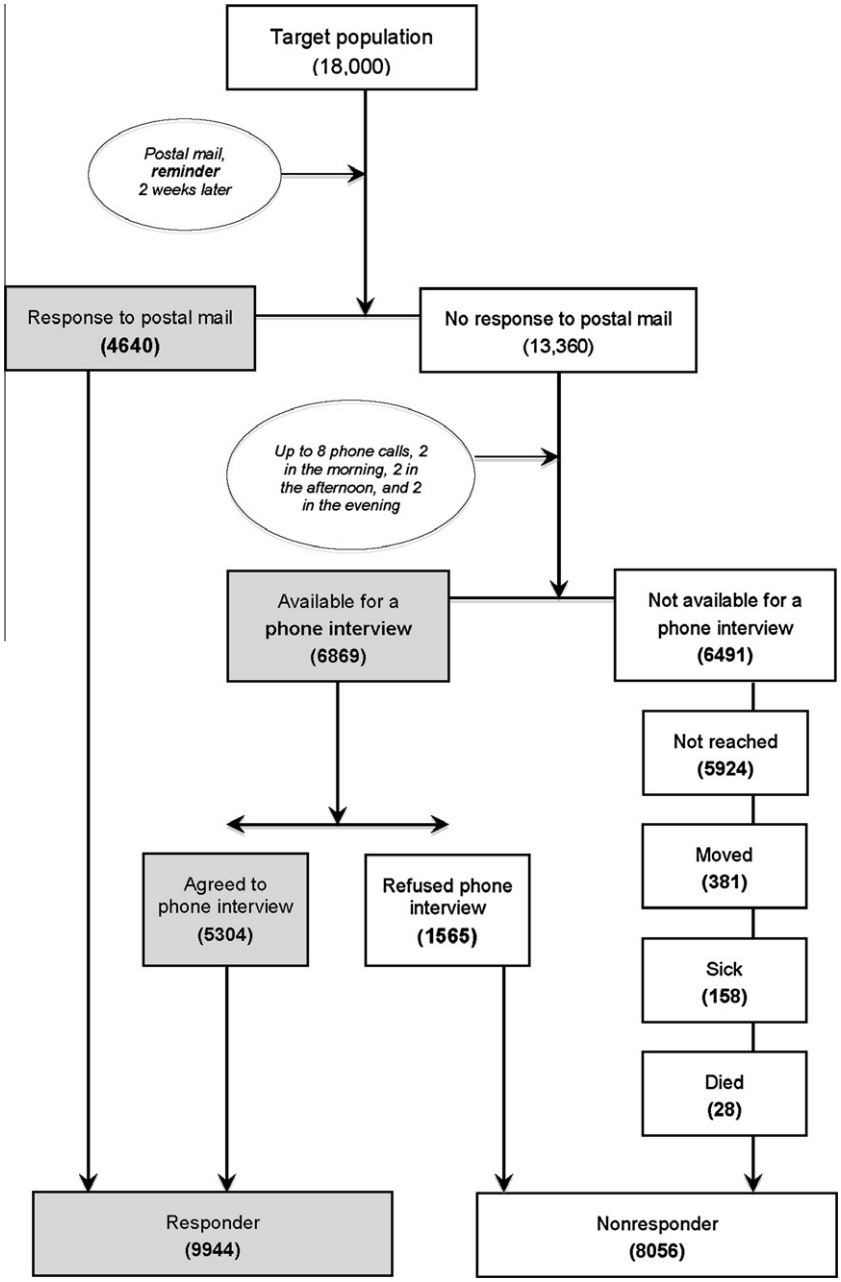

Fig. 1. Screening procedure.

The outcome variable was defined as presence of frequent low back pain (yes vs no), defined as self-reported low back pain occurring on $\geqslant$15 days per month.

Further exploratory analyses were conducted and included a model (Model 4) with the covariate of frequent ($\geqslant$15 days/month) intake of acute pain medication (including any pain or migraine drugs) vs no frequent intake. This analysis was assessed independently, as frequent intake of acute pain drugs is highly associated with both the outcome (low back pain or frequent low back pain) and exposure (headache status).

3. Results

3.1. Description of study population

Of 18,000 individuals surveyed, 9944 (55.2%) responded. Responders were slightly older than nonresponders (43 ± 13.1 vs 39.8 ± 12.6 years) and included more women than men (52.7% vs 46.7%). There were 4030 individuals who reported having no headache during the previous year and represented the No Headache control population; 5605 individuals reported headache in the previous year; of those, 255 had CH and 5350 had EH. Migraine, or those with migraine and including coexisting TTH, was diagnosed in 2933 respondents, of whom 182 had CM and 2751 had EM. Migraine-II, or those with migraine and excluding coexisting TTH, was diagnosed in 1709 respondents, of whom 108 had CM-II and 1601 had EM-II. TTH was diagnosed in 1253 respondents, of whom 50 had CTTH and 1203 had ETTH. Low back pain in the previous year was reported by 6030 respondents; of those, 1267 had frequent low back pain. Table 1 provides a summary of the study population characteristics by headache subtype.

Regarding the frequency of low back pain among headache subtype, 42.5% of those with No Headache, 76.4% of those with EH, and 88.2% of those with CH reported low back pain. Furthermore, low

Table 1
Characteristics of study population.

	No Headache (n = 4030)	EH (n = 5350)	CH (n = 255)	EM (n = 2751)	CM (n = 182)	EM-II (n = 1601)	CM-II (n = 108)	ETTH (n = 1203)	CTTH (n = 50)
Missing	309								
Age, years									
Mean (SD)	46.7 (12.8)	40.2 (12.8)	45.6 (14.1)	39.9 (12.1)	44.7 (13.7)	40.4 (11.8)	45.3 (12.9)	41.1 (12.6)	49.4 (13.9)
Min, Max	18, 66	5, 66	18, 66	5, 66	18, 66	5, 66	18, 66	18, 66	19, 65
Missing, n	2	5	9	2	0	1	0	1	0
Gender, n (%)									
Men	2408 (59.8)	2053 (38.4)	89 (34.9)	919 (33.4)	50 (27.5)	466 (29.1)	29 (26.9)	505 (42.0)	26 (52.0)
Women	1622 (40.2)	3297 (61.6)	166 (65.1)	1832 (66.6)	132 (72.5)	1135 (79.9)	79 (73.1)	698 (58.0)	24 (48.0)
Missing	0	0	0	0	0	0	0	0	0
Drinking, n (%)									
No	3086 (76.6)	4811(89.9)	22 (88.2)	2513 (91.4)	167 (91.8)	1467 (91.6)	97 (89.8)	1069 (89.0)	38 (76.0)
Yes[a]	555 (13.8)	456 (8.5)	24 (9.4)	196 (7.1)	10 (5.5)	106 (6.6)	8 (7.4)	115 (9.5)	11 (22.0)
Missing	389 (9.6)	83 (1.6)	6 (2.4)	42 (1.5)	5 (2.7)	28 (1.8)	3 (2.8)	19 (1.5)	1 (2.0)
Smoking, n (%)									
No	2581 (64.0)	3676 (68.7)	142 (55.7)	1834 (66.7)	93 (51.1)	1071 (66.9)	62 (57.4)	839 (69.7)	32 (64.0)
Yes[b]	1075 (26.7)	1615 (30.2)	109 (42.7)	892 (32.4)	86 (47.3)	513 (32.0)	44 (40.7)	350 (29.1)	17 (34.0)
Missing	374 (9.3)	59 (1.1)	4 (1.6)	25 (0.9)	3 (1.6)	17 (1.1)	2 (1.9)	14 (1.2)	1 (2.0)
Education, n (%)									
High[c]	1005 (24.9)	1987 (37.1)	51 (20.0)	952 (34.6)	32 (17.6)	548 (34.2)	20 (18.5)	470 (39.1)	12 (24.0)
Low	2587 (64.1)	3251 (60.8)	201 (78.8)	1746 (63.5)	147 (80.8)	1018 (63.6)	86 (79.6)	715 (59.4)	38 (76.0)
Missing	438 (12.1)	112 (2.1)	3 (1.2)	53 (1.9)	3 (1.6)	35 (2.2)	2 (1.9)	18 (1.5)	0 (0)
BMI, n (%)									
⩽25	1784 (44.3)	3097 (57.9)	113 (44.3)	1614 (58.7)	83 (45.6)	946 (59.1)	45 (41.7)	693 (57.6)	20 (40.0)
25–30	1306 (32.4)	1520 (28.4)	96 (37.7)	747 (27.2)	66 (36.3)	421 (26.3)	43 (39.8)	351 (29.2)	23 (46.0)
⩾30	479 (11.9)	587 (11.0)	39 (15.3)	320 (11.6)	30 (16.5)	192 (12.0)	19 (17.6)	129 (10.7)	5 (10.0)
Missing	461 (11.4)	146 (2.7)	7 (2.7)	70 (2.5)	3 (1.6)	42 (2.6)	1 (0.9)	30 (2.5)	2 (4.0)
LBP[d], n (%)									
Yes	1715 (42.5)	4090 (76.4)	225 (88.2)	2211 (80.4)	164 (90.1)	1274 (79.6)	97 (89.8)	905 (75.2)	41 (82.0)
No	1916 (47.5)	1236 (23.1)	28 (11.0)	531 (19.3)	17 (9.3)	320 (20.0)	10 (9.3)	293 (24.4)	9 (18.0)
Missing	399 (10.0)	24 (0.5)	2 (0.8)	9 (0.3)	1 (0.6)	7 (0.4)	1 (0.9)	5 (0.4)	0 (0)
Frequent LBP[e], n (%)									
Yes	314 (7.8)	807 (15.1)	146 (57.3)	478 (17.4)	109 (59.9)	279 (17.4)	66 (61.1)	170 (14.1)	29 (58.0)
No	3212 (79.7)	4363 (81.5)	97 (38.0)	2179 (79.2)	68 (37.4)	1263 (78.9)	39 (36.1)	988 (82.1)	20 (40.0)
Missing	504 (12.5)	180 (3.4)	12 (4.7)	94 (3.4)	5 (2.7)	59 (3.7)	3 (2.8)	45 (3.8)	1 (2.0)
Frequent medication intake[f], n (%)									
Yes	74 (1.8)	224 (4.2)	122 (47.9)	163 (6.0)	99 (54.4)	105 (6.6)	54 (50.0)	33 (2.7)	15 (30.0)
No	3442 (85.4)	4590 (85.8)	109 (42.7)	2312 (84.0)	65 (35.7)	1337 (83.5)	41 (38.0)	1056 (87.8)	30 (60.0)
Missing	514 (12.8)	536 (10.0)	24 (9.4)	276 (10.0)	18 (9.9)	159 (9.9)	13 (12.0)	114 (9.5)	5 (10.0)

EH, episodic headache; CH, chronic headache; EM, episodic migraine with coexisting tension-type headache (TTH); CM, chronic migraine with coexisting TTH; EM-II, episodic migraine with no coexisting TTH; CM-II, chronic migraine with no coexisting TTH; ETTH, episodic TTH; CTTH, chronic tension-type headache; BMI, body mass index; LBP, low back pain.

[a] Drinking (yes) was defined as daily or almost daily drinking of alcoholic beverage, and Drinking (no) was defined as no or casual drinking of alcoholic beverages.

[b] Smoking (yes) was defined as current smoking, and Smoking (no) was defined as never or past smoking.

[c] High education was defined as completion of high school or University, and Low education was defined as any other response.

[d] Low back pain was defined as the presence of low back pain within the past 3 months.

[e] Frequent low back pain was defined as low back pain occurring on ⩾15 days/per month within the past 3 months.

[f] Frequent medication intake was defined as intake of acute pain drugs medication (including any pain and or migraine drugs) on ⩾15 days/month within the past 3 months.

back pain occurred at a higher rate in the chronic vs episodic headache subtypes, as well as at a higher rate in the migraine vs TTH subtypes (Table 1). Regarding the frequency of frequent low back pain among headache subtypes, 7.8% of those with No Headache, 15.1% of those with EH, and 57.3% of those with CH reported frequent low back pain. Similarly, frequent low back pain occurred at a higher rate in the chronic vs episodic headache subtypes, as well as at a higher rate in the migraine vs TTH subtypes (Table 1).

3.2. Association of low back pain among headache subtypes

Headache subtype (Chronic and Episodic vs reference group of No Headache) was the primary predictor of interest. Both univariate (Model 1) and multivariate analyses (Models 2 and 3) demonstrated significantly higher rates of low back pain among the episodic and chronic headache subtypes when compared to those with No Headache. After adjusting for demographic features (age and gender), smoking and drinking status, education, and BMI (Table 2; Model 3, rows 5-6), the odds of having low back pain were elevated in persons with EH (odds ratio [OR] 3.8; 95% confidence interval [CI] 3.4-4.2) and even more elevated in persons with CH (OR 8.0; 95% CI 5.3-12.1) compared to those with No Headache.

After adjusting for all covariates (Table 2: Model 3, rows 9-10 and 13-14) in the migraine subtypes, the odds of having low back pain were elevated in persons with EM (OR 4.8; 95% CI 4.2-5.5) and again even more elevated in persons with CM (OR 9.3; 95% CI 5.6-15.5) compared to those with No Headache. Nearly identical rates were demonstrated for the EM-II (OR 4.6; 95% CI 4.0-5.4) and CM-II (OR 9.5; 95% CI 4.9-18.4) groups.

Findings for TTH differed in magnitude but not trend from the headache and migraine subtypes. After adjusting for covariates (Table 2: Model 3, rows 17-18), the odds of having low back pain

Table 2
Model assessing the association between low back pain and headache subtypes.

	Model 1[a]		Model 2[b]		Model 3[c]		Model 4[d]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Headache[e]		n = 9212		n = 9205		n = 8611		n = 7921
No	Ref.		Ref.		Ref.		Ref.	
EH	3.7	3.4-4.0	3.9	3.5-4.3	3.8	3.4-4.2	4.2	3.8-4.7
CH	9.0	6.0-13.4	8.8	5.9-13.1	8.0	5.3-12.1	5.3	3.4-8.1
Migraine		n = 6556		n = 6552		n = 6099		n = 5652
No	Ref.		Ref.		Ref.			
EM	4.6	4.1-5.2	5.0	4.4-5.6	4.8	4.2-5.5	5.3	4.6-6.1
CM	10.8	6.5-17.8	10.8	6.5-18.0	9.3	5.6-15.5	5.7	3.3-9.8
Migraine-II		n = 5334		n = 5331		n = 4940		n = 4601
No	Ref.		Ref.		Ref.			
EM-II	4.4	3.9-5.1	4.7	4.1-5.5	4.6	4.0-5.4	5.1	4.3-6.0
CM-II	10.8	5.6-20.8	10.9	5.6-21.0	9.5	4.9-18.4	5.2	2.6-10.4
TTH		n = 4881		n = 4878		n = 4524		n = 4223
No	Ref.		Ref.		Ref.			
ETTH	3.4	3.0-4.0	3.6	3.1-4.2	3.5	3.0-4.1	3.9	3.3-4.6
CTTH	5.1	2.5-10.5	4.9	2.4-10.2	4.4	2.1-9.2	3.0	1.4-6.4

OR, odds ratio; CI, confidence interval; EH, episodic headache; CH, chronic headache; EM, episodic migraine with coexisting tension-type headache (TTH); CM, chronic migraine with coexisting TTH; EM-II, episodic migraine with no coexisting TTH; CM-II, chronic migraine with no coexisting TTH; ETTH, episodic tension-type headache; CTTH, chronic tension-type headache.

[a] Model 1: Crude.

[b] Model 2: Model 1 + adjusted for age (continuous), gender (binary).

[c] Model 3: Model 2 + adjusted for smoking status (binary), drinking status (binary), education level (binary), BMI (tertiary).

[d] Model 4: Model 3 + adjusted for frequent medication intake.

[e] Model sample sizes differ because respondents can have missing data for covariates (eg, if a respondent reported age and gender but did not report smoking status, he/she would be included in Model 1 but not Model 3).

were elevated in persons with ETTH (OR 3.5; 95% CI 3.0-4.1) as well as persons with CTTH (OR 4.4; 95% CI 2.1-9.2) compared to those with No Headache.

3.3. Association of frequent low back pain among headache subtypes

Findings for frequent low back pain analyses differed largely in magnitude of the OR, but not in overall significance, from models assessing the odds of low back pain presence. Both univariate and multivariate analyses (Models 1-3) demonstrated significantly higher rates of frequent low back pain among the episodic and chronic headache subtypes. Generally, in unadjusted and adjusted models, the odds of having frequent low back pain were about twice as high in those with the EH subtype compared to No Headache. However, the odds of having frequent low back pain were between 13.7 and 18.3 times higher in those with the CH subtype compared to No Headache. After adjusting for covariates (Table 3; Model 3, rows 5-6), the odds of having frequent low back pain were elevated in persons with EH (OR 2.3; 95% CI 2.0-2.7) and were substantially elevated in persons with CH (OR 14.5; 95% CI 10.7-19.6) compared to those with No Headache.

After adjusting for all covariates (Table 3; Model 3, rows 9-10 and 13-14) in the migraine subtypes, the odds of having frequent low back pain were elevated in persons with EM (OR 2.7; 95% CI 2.3-3.2) and again were substantially elevated in persons with CM (OR 15.2; 95% CI 10.7-21.5) compared to those with No Headache. A similar trend was seen in the Migraine-II subsets (EM-II: OR 2.6; 95% CI 2.1-3.2, and CM-II: OR 15.8; 95% CI 10.2-24.5).

For frequent low back pain, findings for TTH differed in magnitude but not trend from the headache and migraine subtypes. After adjusting for covariates (Table 3; Model 3, rows 17-18), the odds of having low back pain were elevated in persons with ETTH (OR 2.1; 95% CI 1.7-2.7) as well as persons with CTTH (OR 13.7; 95% CI 7.4-25.3) compared to those with No Headache.

3.4. Exploratory analyses

After adjusting for intake of acute pain drugs, results differed in magnitude of the odds ratio, but not in overall significance (Tables 2 and 3; Model 3 vs Model 4). Regarding the general trend, the odds ratios for the association of low back pain as well as frequent low back pain and the episodic headache subtypes (ie, EH, EM, EM-II, and ETTH) remained fairly consistent between Model 3 and Model 4. However, the magnitude of the odds ratio for the association of low back pain and frequent low back pain and the chronic headache subsets (ie, CH, CM, CM-II, and CTTH) declined substantially after adjusting for intake of acute pain drugs. This analysis was assessed independently and as exploratory, however, because the intake of acute pain drugs is highly associated with both the outcome (back pain) and exposure (headache status). There is also a high correlation between frequent back pain and increased intake of acute pain drugs.

4. Discussion

We aimed to investigate whether migraine and TTH and their episodic and chronic forms might be associated with low back pain and frequent low back pain. We therefore analyzed cross-sectional data of a large population-based sample in Germany and found that, compared to those who do not experience headaches, people diagnosed with a headache condition, including its 2 most prevalent primary types, migraine and TTH, were significantly more likely to suffer from low back pain (OR 3.4-10.9). Striking results were found when we analyzed the association between chronic and episodic headache (migraine and tension-type headache) forms with frequent low back pain. We found that the likelihood of having comorbid frequent low back pain was significantly higher in respondents with chronic headache (OR 13.7-18.3) and episodic headache forms (OR 1.8-2.7) than it was in those without headache.

Although the prevalence of migraine appears high (n = 2933, 29%) in this analysis, this is due to including all subjects with

Table 3
Models assessing association between frequent low back pain and headache subtypes.

	Model 1[a]		Model 2[b]		Model 3[c]		Model 4[d]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Headache[e]		n = 8939		n = 8933		n = 8365		n = 7719
No	Ref.		Ref.		Ref.		Ref.	
EH	1.9	1.6-2.2	2.3	2.0-2.6	2.3	2.0-2.7	2.3	2.0-2.8
CH	15.4	11.6-20.4	16.5	12.4-22.1	14.5	10.7-19.6	8.0	5.6-11.3
Migraine		n = 6360		n = 6357		n = 5929		n = 5510
No	Ref.		Ref.		Ref.		Ref.	
EM	2.2	1.9-2.6	2.7	2.3-3.2	2.7	2.3-3.2	2.7	2.2-3.2
CM	16.4	11.9-22.7	18.1	12.9-25.4	15.2	10.7-21.5	7.3	4.8-11.0
Migraine-II		n = 5173		n = 5170		n = 4800		n = 4486
No	Ref.		Ref.		Ref.		Ref.	
EM-II	2.3	1.9-2.7	2.6	2.2-3.2	2.6	2.1-3.2	2.5	2.0-3.2
CM-II	17.3	11.5-26.1	18.3	11.9-28.0	15.8	10.2-24.5	7.5	4.5-12.8
TTH		n = 4733		n = 4733		n = 4389		n = 4112
No	Ref.		Ref.		Ref.		Ref.	
ETTH	1.8	1.4-2.1	2.1	1.7-2.6	2.1	1.7-2.7	2.2	1.7-2.8
CTTH	14.8	8.3-26.5	14.8	8.1-26.9	13.7	7.4-25.3	8.1	4.2-16.2

OR, odds ratio; CI, confidence interval; EH, episodic headache; CH, chronic headache; EM, episodic migraine with coexisting tension-type headache (TTH); CM, chronic migraine with coexisting TTH; EM-II, episodic migraine with no coexisting TTH; CM-II, chronic migraine with no coexisting TTH; ETTH, episodic tension-type headache; CTTH, chronic tension-type headache.

[a] Model 1: Crude.

[b] Model 2: Model 1 + adjusted for age (continuous) and gender (binary).

[c] Model 3: Model 2 + adjusted for smoking status (binary), drinking status (binary), education (binary), and BMI (tertiary).

[d] Model 4: Model 3 + adjusted for frequent medication intake.

[e] Model sample sizes differ because respondents can have missing data for covariates (eg, if a respondent reported age and gender but did not report smoking status, he/she would be included in Model 1 but not Model 3).

migraine and coexisting tension-type headache. An interest bias might contribute to the relatively high prevalence as well. Details of the prevalence of primary headache within the German community have been presented previously and are comparable to other European and US prevalence studies [43,45,63,64,75].

Results of our study are in line with the international literature. Population- and clinic-based studies suggest that, in general, headache, particularly migraine, is comorbid with low back pain [29,33–35] as well as with other pain conditions [30] such as fibromyalgia [21,53], facial pain [76], and temporomandibular disorders [56].

Furthermore, population-based and observational studies have shown an association between chronic pain/pain disorders and migraine, with significantly greater frequency in those with CM [10,14]. Additionally, studies suggest that migraine is comorbid with affective disorders such as chronic fatigue [1,54,67], anxiety [12,38,48,57], and depression [13,78], with anxiety and depression having greater frequency among persons with CM compared to those with EM [10,14].

Regarding these findings, we assumed that several variables such as age, female gender, smoking, low level of education, and obesity could potentially influence the association between headache and low back pain. Obesity has been demonstrated as an important independent risk factor for both low back pain [62] and migraine, including CM [14]. Like smoking and low education level, obesity is related to lower socioeconomic status, which has also been demonstrated to be strongly associated with chronic headache [6,14,39,72] and low back pain [32]. For our analyses, we therefore adjusted for the above-mentioned factors and still found a very strong association between all chronic headache subtypes and low back pain as well as frequent low back pain.

Special attention was given to frequent use of acute pain and headache drugs. The International Headache Society commonly uses the term "medication overuse," which is a well-known risk factor for developing chronic headache [9,40,79]. The large Norwegian Head-Hunt study demonstrated that medication overuse plays an important role in developing frequent low back pain as well [80]. Given this understanding and the knowledge that similar acute pain medications are used to treat frequent low back pain and chronic headache, we suspected that there would be a direct correlation between intake of acute pain drugs and increased headache day frequency (ie, chronicity) as well as frequent low back pain. We therefore performed exploratory analyses that factored intake of acute pain drugs into the final model; as anticipated, our results demonstrated similar correlations, although with lower odds ratios.

Recently, Plesh et al. reported about "self-reported comorbid pains in severe headaches or migraine in a US national sample" [55]. In a large study sample (n = 189,967 adults), more than 60% of the entire study population had at least one comorbid pain, and 33% reported 2 or more comorbid pain conditions. The authors conclude that severe headache conditions were more associated with other common pain syndromes like neck, back, and joint pain. In Spain, subjects between 31 and 50 years of age were more likely to report low back pain that was significantly associated with headaches [25]. However, these studies do not take headache subtypes or even headache frequencies and medication overuse into their consideration. Chronic daily headache with special emphasis on migraine and its associated factors are extensively discussed [8].

Our results show that low back pain was associated with chronic daily headache. An important finding of the study is that the association between chronic headaches and frequent low back pain is not specific to migraine or tension-type headache. The driving force appears to be the chronicity of headache itself. Our findings fit well into the current concept of the pathophysiology of chronification of headache and pain, which most likely involves the entire central pain matrix.

Findings from electrophysiological studies support this assumption. The pathophysiological basis of chronic pain conditions is most probably abnormal facilitation of the trigeminal and extratrigeminal pain pathways. In support, studies using pain-evoked potentials have demonstrated facilitation of the trigeminal nociceptive system in CM [20] and CTTH [19], as well as in chronic

cluster headache [36] and trigeminal neuralgia with chronic facial pain [52]. Similar abnormal facilitatory changes were demonstrated using the same electrophysiological techniques in chronic extracranial painful disorders, such as fibromyalgia [18].

Based on neuroimaging studies, functional or structural changes that occur during migraine attacks have been documented in the brain regions responsible for central pain processing, such as the brain stem [7,49,71], trigeminal somatosensory pathway [17], primary somatosensory cortex [16], and posterior parietal cortex [41,71]. It has been postulated that the repeated activation of the trigeminal pathway and consequently, the modular pain pathways in the periaqueductal gray matter, may promote structural changes in chronic pain conditions [4]. Voxel-based morphometry (VBM) has demonstrated that patients with migraine and T2-visible single alterations had increased density in periaqueductal gray matter and the dorsolateral pons, with a decrease in volume of gray matter in the anterior cingulate cortex and in the bilateral insula, compared to healthy controls [58]. In both migraine and CM patients, VBM has demonstrated significant gray matter reductions in several cortical areas within the pain matrix, with a correlation between frequency of migraine attacks and signal alteration in the anterior cingulated cortex [69]. Patients with CTTH based on VBM also had a significant decrease in gray matter, compared to controls, in cortical areas involved in pain processing [61]. Similar results were observed with VBM in several chronic pain syndromes, including fibromyalgia [42], phantom pain [22], chronic back pain [2,60], and thoracic spinal cord injury [74], where there was a decrease in the gray matter volume in the brain areas involved in nociceptive processing. Collectively, these data have led to the hypothesis that there is a specific signature within the brain in patients who suffer from chronic pain [47].

In addition to gaining insights into the chronification process, our findings are important for clinical practice. In patients presenting with CM, CTTH, or frequent low back pain, given the strong association among these conditions, attention should be paid to other pain comorbidities. Understanding the association with comorbid pain disorders is important in our efforts to provide optimal care, as patients with comorbidities may have different responses to treatment paradigms than those patients experiencing only one condition. For example, CTTH patients with comorbid psychiatric disorders have been found to respond better to antidepressant medications than those without a comorbid psychiatric disorder in a randomized, controlled study [37]. However, future studies are needed to evaluate and quantify possible links between the treatment of comorbidities and reduction in the burden of headache as well as other pain disorders [3].

There are several strengths of this study: the large representative population-based sample in 3 different regions of Germany; the use of questionnaires that were validated and published prior to the study; and the large number of outcomes, due to the initially large sample size, which provided enough power to test a number of predefined covariates.

This study has limitations, as well, including the fact that a potentially important moderating variable, depression status, was not collected in the questionnaire and was therefore not included in the analyses. It is unknown whether depression is on the causal pathway or a consequence of chronicity, but there is recent evidence suggesting it is linked to chronic migraine progression (Sait, Serrano, et al., 2012 AMPP study depression paper, under review). When possible, comorbid depression should be considered when assessing differences between chronic and episodic headache disorders. Additionally, our self-report diagnosis of low back pain and frequent low back pain was not robust as a clinical assessment, and as such, we could not determine if it was related to acute or subacute injuries. Regarding more general limitations, the overall response rate of the survey was 55%, which is satisfactory in comparison to other large-scale population-based studies in Western Europe and the US, but poses a possible selection bias, as very old and very young people often do not participate in surveys, and more affected persons tend to participate more eagerly than nonaffected healthy persons. Also, we cannot report clinical details and causes in respondents with low back pain. These limitations are not unique to our study, as most large-scale, questionnaire-based surveys face these challenges.

Conflicts of interest statement

Min-Suk Yoon has nothing to disclose. Aubrey Manack is an employee of and holds stock in Allergan, Inc. Sara Schramm has nothing to disclose. Guenther Fritsche has nothing to disclose. Mark Obermann has received scientific support and/or honoraria from Biogen Idec, Novartis, Sanofi-Aventis, Pfizer, and Teva. He received research grants from the German Ministry for Education and Research (BMBF). Hans-Christoph Diener has been a consultant for and is a member of the speakers' bureau of Allergan, Inc. Susanne Moebus has nothing to disclose. Zaza Katsarava has received grants and research support, been a consultant for, and is a member of the speakers' bureau of Allergan, Inc.

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