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Title	Craniofacial Pain and Jaw-muscle Activity during Sleep
Author(s)	Yachida, W.; Castrillon, E.E.; Baad-Hansen, L. et al.
Citation	Journal of Dental Research, 91(6), 562-567 https://doi.org/10.1177/0022034512446340
Issue Date	2012-06-01
Doc URL	https://hdl.handle.net/2115/72855
Type	journal article
File Information	TMD-TTH-GC-Manuscript-Rev2.pdf

Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

Craniofacial pain and jaw-muscle activity during sleep

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Abstract

This study aimed to compare the jaw-muscle electromyographic (EMG) activity during sleep in patients with painful (n=59, 36.8±12.1 years) or non-painful (n=56, 31.5±10.8 years) temporomandibular disorders (TMD), tension-type headache (TTH: n=30, 33.3±9.6 years), and in healthy controls (n=30, 26.2±3.9 years). All participants used a portable single-channel EMG device (GrindCare3™, MedotechA/S) for one week. There was no significant difference in EMG activity between painful TMD (23.9±18.0) and non-painful TMD (20.7±14.8), or between TTH (20.8±15.0) and healthy subjects (15.2±11.6, P>.050). There were, however, correlations between EMG activity and number of painful muscles (r=0.188; P=.044), characteristic pain intensity (r=0.187; P=.046), McGill Pain Questionnaire (r=0.251; P=.008) and depression scores (r=0.291; P=.002). Subjects with painful conditions had significantly higher night-to-night variability compared with pain-free subjects (P<.050). Overall, there seems to be no major differences between different craniofacial pain conditions and healthy controls in jaw-muscle EMG activity recorded with a single-channel EMG device during sleep. However, some associations may exist between the level of EMG activity and various parameters of craniofacial pain. Further studies are warranted.

Key words: myofascial pain, sleep bruxism, portable electromyographic device,

temporomandibular disorders, tension-type headache, jaw-muscle activity.

Introduction

Temporomandibular disorders (TMD) and headache are frequent craniofacial pain conditions in the general population (Jensen and Stovner, 2008; LeResche, 1997). Tension-type headache (TTH) is the most common primary headache (Scher et al., 1998). Sleep bruxism (SB) has been considered to be a risk factor for both TMD and TTH (Baba et al., 2005; Bailey, 1990; Rossetti et al., 2008; Vendrame et al., 2008) and is defined as a sleep-related movement disorder characterized by grinding/clenching of the teeth during sleep and associated with excessive arousal responses (AASM, 2005).

Portable single channel electromyograhic (EMG) recordings have been used to measure SB activity because this method enables multiple night recording in subjects' homes at relatively low costs (Pierce and Gale, 1988; Rugh and Solberg, 1975). In order to understand SB and its potential consequences on oral function and health, a better description of jaw-muscle activity in different craniofacial pain conditions will be needed. Some studies reported the characteristics of jaw-muscle EMG activity in subjects with SB and TMD symptoms (Camparis et al., 2006; van Selms et al., 2008). However, the relationship between SB and TMD/TTH is still controversial and remains unclear (Manfredini and Lobbezoo, 2010; Svensson et al., 2008; Vendrame et al., 2008). Further, some researchers have reported a substantial night-to-night variability of SB

activity during polysomnography (PSG) (Lavigne et al., 2001; Van Der Zaag et al., 2008). Thus, long-term (multiple nights) recordings of jaw-muscle activity in both painful conditions and healthy controls are necessary to assess the dynamics of SB activity.

The main aim of this study was to compare the jaw-muscle EMG activity during sleep in patients with or without painful TMD, TTH and in healthy controls. We also aimed to explore the correlation between EMG activity and clinical parameters related to physical status, quality of pain and psychological status. Finally, we tested the night-to-night variability of EMG activity during sleep between the different craniofacial pain conditions.

Materials and Methods

Subjects

A total of 115 participants; 39 men (mean age ± SD: 36.8 ± 14.0 years) and 76 women (32.8 ± 10.2 years) participated in this study. All participants were generally healthy and more than 18 years old. Exclusion criteria were current illness; history of neurologic or psychiatric disorders; sleep disorders (e.g. snoring, sleep apnea, and periodic limb movement); use of prescription medicine or drugs; smoking, alcohol abuse and addiction to coffee; electrode gel allergy; simultaneous participation in another trial with medicine or in trials of medical devices; and user of pace maker. The study was approved by the local ethics committee and conducted in accordance with the Helsinki Declaration. Written informed consent was obtained from all participants.

We recruited the following types of participants: 30 healthy subjects (16 men: 25.3±4.1 years and 14 women: 27.2±3.6 years) who were among students and staff at Aarhus University, Denmark; 55 self-reported SB subjects (16 men: 46.4±14.6 years and 39 women: 36.0±11.5 years) who were asked by flyers and newspaper advertisement and from patients at the Clinical Oral Physiology, Department of Dentistry, Aarhus University, Aarhus, Denmark, and 30 TTH patients (seven men: 41.1±7.4 years and 23 women: 31.0±9.0 years) from the Danish Headache Center,

Glostrup Hospital, Denmark.

All healthy subjects were without TMD in accordance with the Research Diagnostic Criteria for TMD (RDC/TMD) (Dworkin and LeResche, 1992). Furthermore, we examined healthy subjects for clinical signs or symptoms related to SB, 1) self-report or reported by a bed partner of tooth-grinding or clenching habits during sleep; 2) jaw-muscle fatigue/pain upon awakening; 3) masseter muscle hypertrophy on voluntary contraction (Lavigne et al., 2008); 4) moderate to severe hyperkeratosis of cheeks/lips/tongue; 5) advanced tooth wear (≥grade 1c) (Lobbezoo and Naeije, 2001; Wetselaar et al., 2009); 6) loss of cuspid protection; and 7) frequent non-iatrogenic/non-material related fractures and failures of teeth/restorations/implants. All healthy subjects did not report 1) or 2) and had less than two of the other criteria.

Self-reported SB subjects answered “yes” in RDC/TMD questionnaire 15c which is about self-awareness of SB (“Have you been told, or do you notice that you grind your teeth or clench your jaw while sleeping at night?”).

TTH patients were diagnosed as frequent or chronic TTH according to the diagnostic criteria of the second edition of the International Classification of Headache Disorders (ICHD-II) (The International Classification of Headache Disorders: 2nd edition, 2004) using headache diaries in addition to the RDC/TMD examination and

questionnaire.

Study design

On the first day, all participants were asked to fill out the Danish RDC/TMD questionnaire (http://www.rdc-tmdinternational.org) and a Danish version of the McGill Pain Questionnaire (MPQ) (Drewes et al., 1993). The RDC/TMD clinical examination was also performed by standardized examiners (WY, EC, LBH, PS.) who had been calibrated for RDC/TMD and the details of training is showed in the website of International RDC/TMD Consortium (http://www.rdc-tmdinternational.org). Each participant was examined by one examiner. Six self-reported SB subjects did not fill out the MPQ. All participants used a portable EMG device (GrindCare3™, MedotechA/S, Herlev, Denmark) during sleep for at least four nights during one week to measure jaw-muscle activity.

EMG recordings

The GrindCare3™ has a single electrode assembly, with three electrode contacts. The electrode was placed at the anterior temporalis muscle, which generally will provide the same information as EMG recordings from the masseter muscle during sleep (Koyano

et al., 2008). The EMG activity was amplified (x 800) and filtered (250 Hz-610 Hz) in the device and further analyzed for events of EMG activity, using the Signal Recognition Algorithm described in Jadidi et al. (2008). The algorithm is based on a Fast Fourier Transformation analysis and threshold comparison. To determine the individual parameters, the following set-up procedure was performed every night: Subjects were asked to relax their jaw muscle for 10 sec. Then subjects made a grimace for 10 sec and then clenched their teeth around 60% of the maximum voluntary contraction for 10 sec. These procedures were carefully instructed by the examiners and trained together with the participants. The algorithm counts an event when the EMG activity exceeds the signal level at rest, plus 20% of the maximum EMG level during the 60% contraction. After each detection, the system waits for one second, and if the activity is still, or again, above threshold, a new event is counted. The total number of EMG events, the number of EMG events per hour and the number of measurement hours were registered. After one week of measurement had finished, the data were transferred and saved in a PC using commercial software (GrindCare Manager, MedotechA/S, Herlev, Denmark).

Clinical parameters

Four variables from the RDC/TMD questionnaire and clinical examination; maximum pain-free jaw opening, number of painful muscles (0-20), characteristic pain intensity (CPI: 0-100) (Dworkin, 1990) and depression score were selected as secondary outcome clinical parameters. The MPQ was also used to assess the sensory, affective, evaluative, and miscellaneous dimension of pain (Melzack, 1975). The total pain rating index (PRI) was used in the analyses.

Data analysis

All participants were divided into painful and non-painful TMD groups according to the RDC/TMD (Fig.1A). Painful TMD subjects were diagnosed as myofascial pain (RDC/TMD group1ab)/arthralgia (RDC/TMD group3a). Non-painful TMD subjects could have a diagnosis of disc displacement (RDC/TMD group2abc) but without any pain or a diagnosis of osteoarthrosis (RDC/TMD group3c). These groups were also split into with or without self-reported SB (Fig.1B). Then, we compared the EMG data in each group to see the influence of painful TMD/self-reported SB on EMG activity. Further, we compared EMG activity between TTH and healthy subjects. Then, we divided TTH subjects into groups with or without self-reported SB and compared the EMG activity between groups. The coefficient of variation from the multiple night

recordings (CV: SD/mean) was calculated for all individuals in each group to examine the night-to-night variability in EMG activity.

Finally, we analyzed the correlation between EMG activity and some clinical variables derived from the RDC/TMD questionnaire and clinical examination and MPQ.

Statistics

The data are presented as mean±standard deviation (SD). We used non-paired *t*-tests to analyze EMG data and CV between with and without painful TMD groups. Two-way analysis of variance (ANOVA) was used to test the effect of painful TMD and self-reported SB on EMG activity and CV. When appropriate, post-hoc tests were performed with Tukey tests (with correction for multiple comparisons). We also used non-paired *t*-tests to analyze EMG activity and CV between TTH and healthy subjects and between TTH with and without self-reported SB. Spearman correlation tests were used to test the association between EMG activity and clinical parameters. The level of significance was set at $P<.050$.

Results

Between group differences

There was no significant difference in EMG activity between painful and non-painful TMD groups (painful: 23.9 ± 18.0, non-painful: 20.7 ± 14.8, *t*-test, P=.307, Fig.2A). There was no significant effect of painful TMD (F=0.023, P=.879), but a significant effect of self-reported SB (F=9.225, P<.050), with no significant interaction between factors (F=0.153, P=.697, Fig.2B). Self-reported SB subjects had significantly higher EMG activity compared with non- SB subjects (Tukey, P<.050, Fig.2B). There was no significant difference between TTH patients (20.8 ± 15.0) and healthy subjects (15.2 ± 11.6) in EMG activity (*t*-test, P =.108, Fig.2C) or between TTH patients with and without self-reported SB (*t*-test, P=.294, Fig.2D). All participants had measurement times > 6 hours.

Night-to-night variability

Painful TMD patients had significantly higher CV compared with non-painful TMD subjects (*t*-test, P<.050, Fig.3A). There was a significant effect of painful TMD (F=7.779, P<.050), but no significant effect of self-reported SB (F=2.032, P=.157), with no significant interaction between factors (F=2.515, P=.116, Fig.3B). There were

significant difference in CV between painful TMD and non-painful TMD (Tukey, P<.050, Fig. 3B). TTH patients had significantly higher CV compared with healthy subjects (*t*-test, P<.050, Fig.3C). There was no significant difference between TTH with and without self-reported SB (*t*-test, P=.256, Fig.3D).

Correlation between EMG activity and clinical parameters

There were significant positive correlations between the number of EMG events per hour sleep and number of painful muscles (r=0.188, P=.044), CPI (r=0.187, P=.046), depression scores (r=0.291, P=.002) and MPQ (r=0.251, P=.008, Fig. 4).

Discussion

The main finding in this study was the lack of significant differences in EMG activity during sleep between patients with craniofacial pain conditions (TMD, TTH) and healthy control subjects. In a previous study, Rossetti et al. (2008) reported that rhythmic masticatory muscle activity (RMMA) during sleep was weakly associated with myofascial pain by PSG recordings (n=60) which was regarded as the gold standard for assessing SB. In contrast, van Selms et al. (2008) reported no relationship between masticatory muscle activity during sleep and muscle pain using an ambulatory EMG device (n=4). In this study, there was no significant difference in EMG activity between subjects with painful conditions and pain-free subjects. Further, we did an additional analysis comparing the EMG activity between painful TMD/TTH (n=63) and non-painful groups (without TMD pain and TTH; n=52) which did not indicate any significant differences between the groups. However, there was a significant correlation between EMG activity and CPI, and painful TMD and TTH patients had higher CV compared with pain-free subjects. Perhaps certain types or characteristics of muscle activities (intensity, duration, frequency, direction of forces) may be associated with craniofacial pain conditions, and painful conditions may increase the variability. The causal relationship between SB and painful conditions is still a matter of discussion

(Svensson et al., 2008) and the present study design does not allow any definitive conclusions on the causal relationships between SB and craniofacial pain. We showed, however, that jaw-muscle EMG activity during sleep cannot be discriminated between different craniofacial pain conditions. Another important result was that EMG activity during sleep was strongly influenced by self-reports of SB in the entire study group but not specifically in TTH patients. TTH could reduce the reliability of self-awareness of SB. The reliability of self-reports of SB is generally low (Koyano et al., 2008) and may have influenced our findings. Further research would be needed to reveal to what extent painful conditions affect self-reports of SB.

Lavigne et al. (2001) reported that the CV was 25.3% for the number of EMG episodes per hour of sleep in subjects with SB using PSG recordings. Our study showed higher CV in all groups compared with previous data. This difference could be due to the different way of measurement and analyses but strongly indicates that there is a significant and substantial night-to-night variability in EMG recordings which needs to be taken into consideration when evaluating SB.

There were weak, but significant correlations between EMG activity and depression and MPQ scores. EMG activity during sleep may be much more complex and rather related to psychological/psychosocial status than to physical status. However,

Manfredini and Lobbezoo (2009) concluded that there seems to be no evidence to relate SB with psychosocial factors. The role of psychological/psychosocial factors in the etiology of bruxism would be one of the most debated issues, so we also need more studies to improve our understanding of the relationship between SB and psychological/psychosocial factors. The present finding indicates that a single channel EMG device may be helpful in this respect.

This study has some limitations. The recording term was not same in all participants: some subjects forgot using the device or the measurement was failed. We could not re-record the measurement because of practical issues, large samples with multiple night recordings. Further, ambulatory recording system did not allow researcher-controlled environment, so the reliability of the data would be lower compared with PSG study. It is important to realize these limitations in ambulatory recording study.

In conclusion, there were no major differences between patients with different craniofacial pain conditions and healthy controls in jaw-muscle EMG activity recorded with a single-channel EMG device during sleep. However, some associations may exist between the level of EMG activity and various parameters of craniofacial pain. Further studies are warranted to enhance the understanding of SB and potential consequences

such as painful conditions.

Acknowledgments

We thank N. Caspersen, physical therapist at the Danish Headache Center, for her participation in the recruitment of TTH patients to the study and M. Haugland, who works for MedotechA/S, for his advices to the technical aspects of the study. The study was, in part, supported by MedotechA/S.

Conflicts of interest statement

P. Svensson is a paid consultant for MedotechA/S, R. Jensen is a member of the advisory board of the company and E. Castrillon's post-doc fellowship was partially funded by the company. Neither of the authors have stocks in MedotechA/S.

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Figure legends

Fig. 1

Flowchart of grouping of all participants in analysis of EMG data and CV. (A) is painful TMD (pTMD (+)) and non-painful TMD (pTMD (–)) groups. (B) is painful TMD with or without self-reported SB (pTMD (+) and SB (+) or (–)) and non-painful TMD with and without self-reported group (pTMD (–) and SB (+) or (–)).

Fig. 2

Comparison of the EMG data (the number of EMG events per hour of sleep) between different groups. (A) Painful TMD (pTMD (+)) and non-painful TMD (pTMD (–)) groups, (B) * indicates a significant effect of self-reported SB (ANOVA: $P < .050$) and $^{\#}$ indicates a significant difference between with and without self-reported SB (Tukey: $P < .050$). (C) TTH and healthy groups, (D) TTH with and without self-reported SB groups. Mean values and SD.

Fig. 3

Comparison of CV values between different groups. (A) * indicates significant

difference between painful TMD (pTMD (+)) and non-painful TMD (pTMD (–)) groups (*t*-test: P < .050), (B) * indicates significant effect of painful TMD (ANOVA: P < .050) and # indicates significant difference between painful TMD and non-painful TMD groups (Tukey: P < .050). (C) * indicates significant difference between TTH and healthy groups (*t*-test: P < .050) (D) TTH with and without self-reported SB groups. Mean values and SD.

Fig. 4

Correlation between EMG data (the number of EMG events per hour of sleep) and clinical parameters. (A) Maximum pain-free jaw opening, (B) Number of painful muscles, (C) CPI score, (D) Depression score, (E) MPQ score. Correlation coefficient (r) is from Spearman correlation tests.

Fig. 1

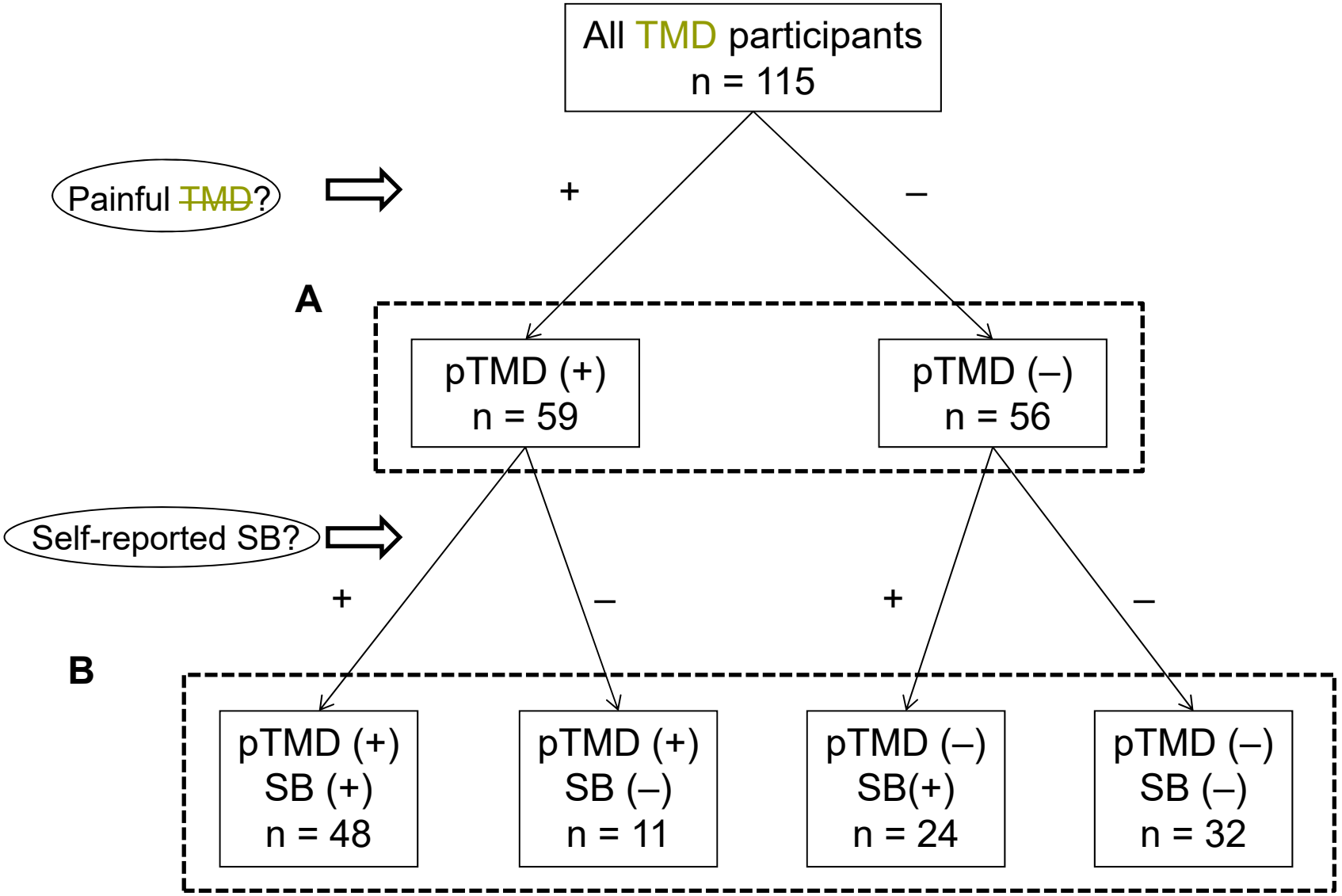

All TMD participants
n = 115
Painful TMD?
+
–
A
pTMD (+)
n = 59
pTMD (–)
n = 56
Self-reported SB?
+
–
+
–
B
pTMD (+)
SB (+)
n = 48
pTMD (+)
SB (–)
n = 11
pTMD (–)
SB(+)
n = 24
pTMD (–)
SB (–)
n = 32

Fig. 2

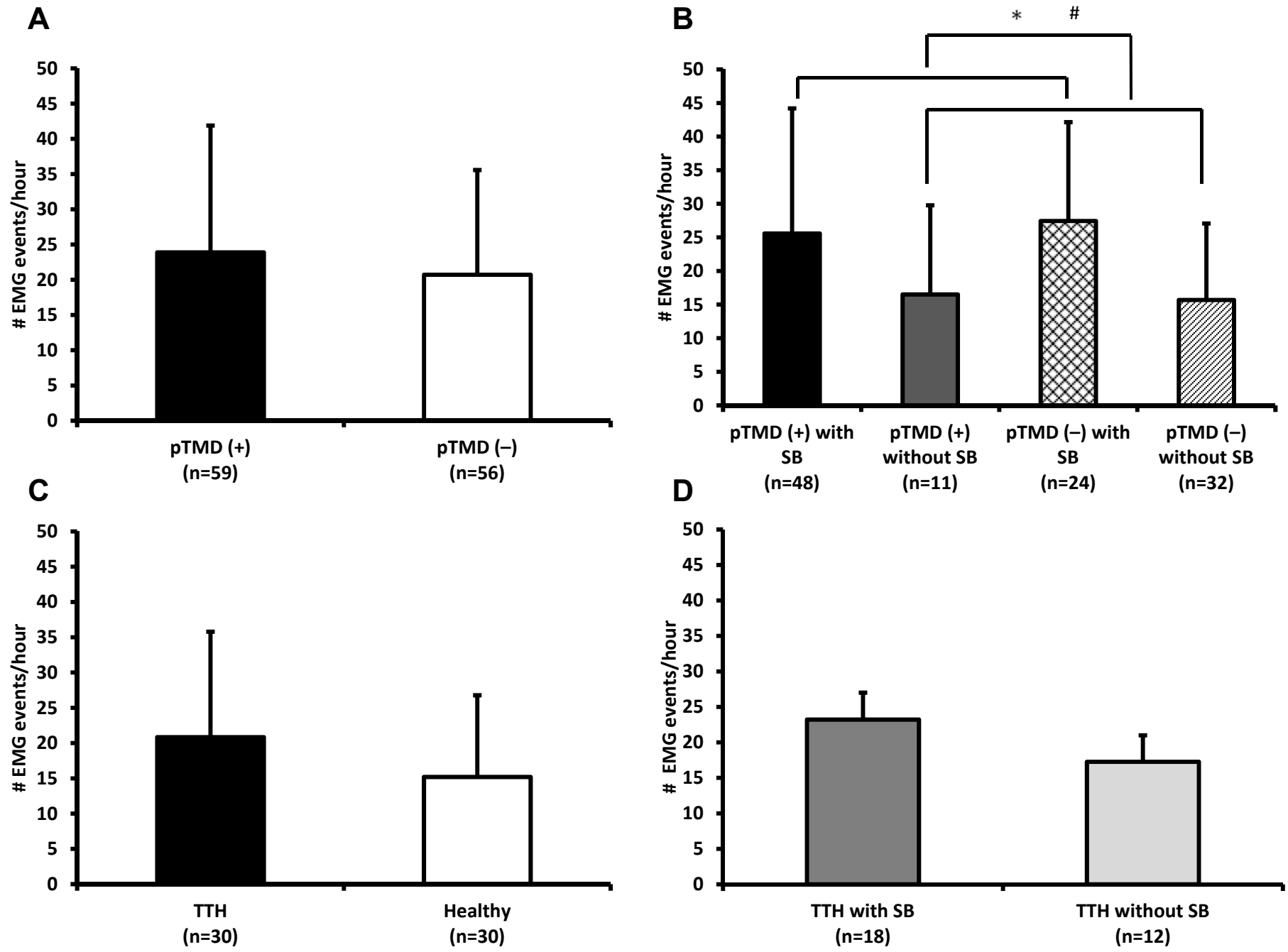

A
EMG events/hour
50
45
40
35
30
25
20
15
10
5
0
pTMD (+)
(n=59)
pTMD (–)
(n=56)
B
*
#
EMG events/hour
pTMD (+) with SB
(n=48)
pTMD (+) without SB
(n=11)
pTMD (–) with SB
(n=24)
pTMD (–) without SB
(n=32)
C
EMG events/hour
TTH
(n=30)
Healthy
(n=30)
D
EMG events/hour
TTH with SB
(n=18)
TTH without SB
(n=12)

Fig. 3

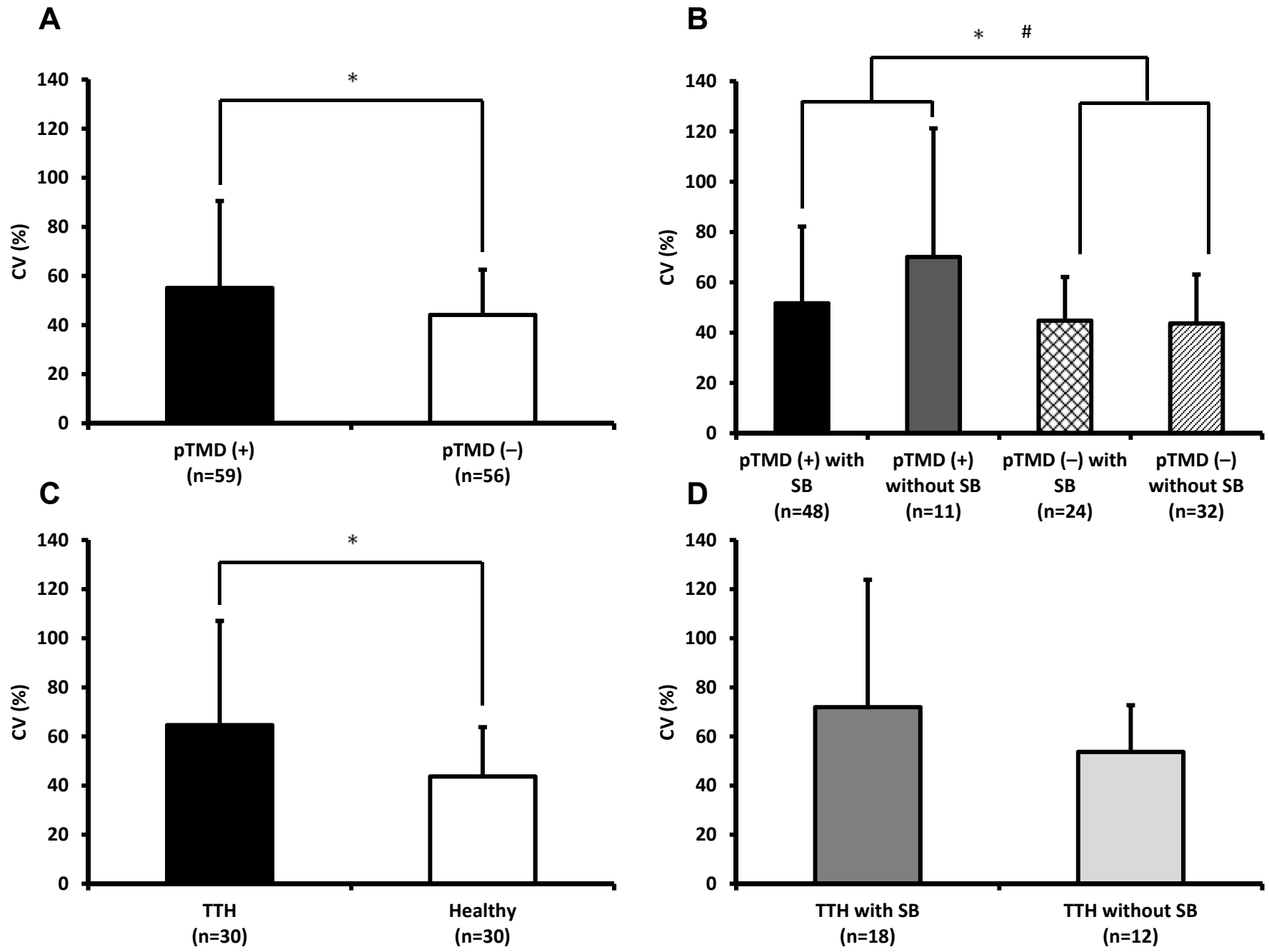
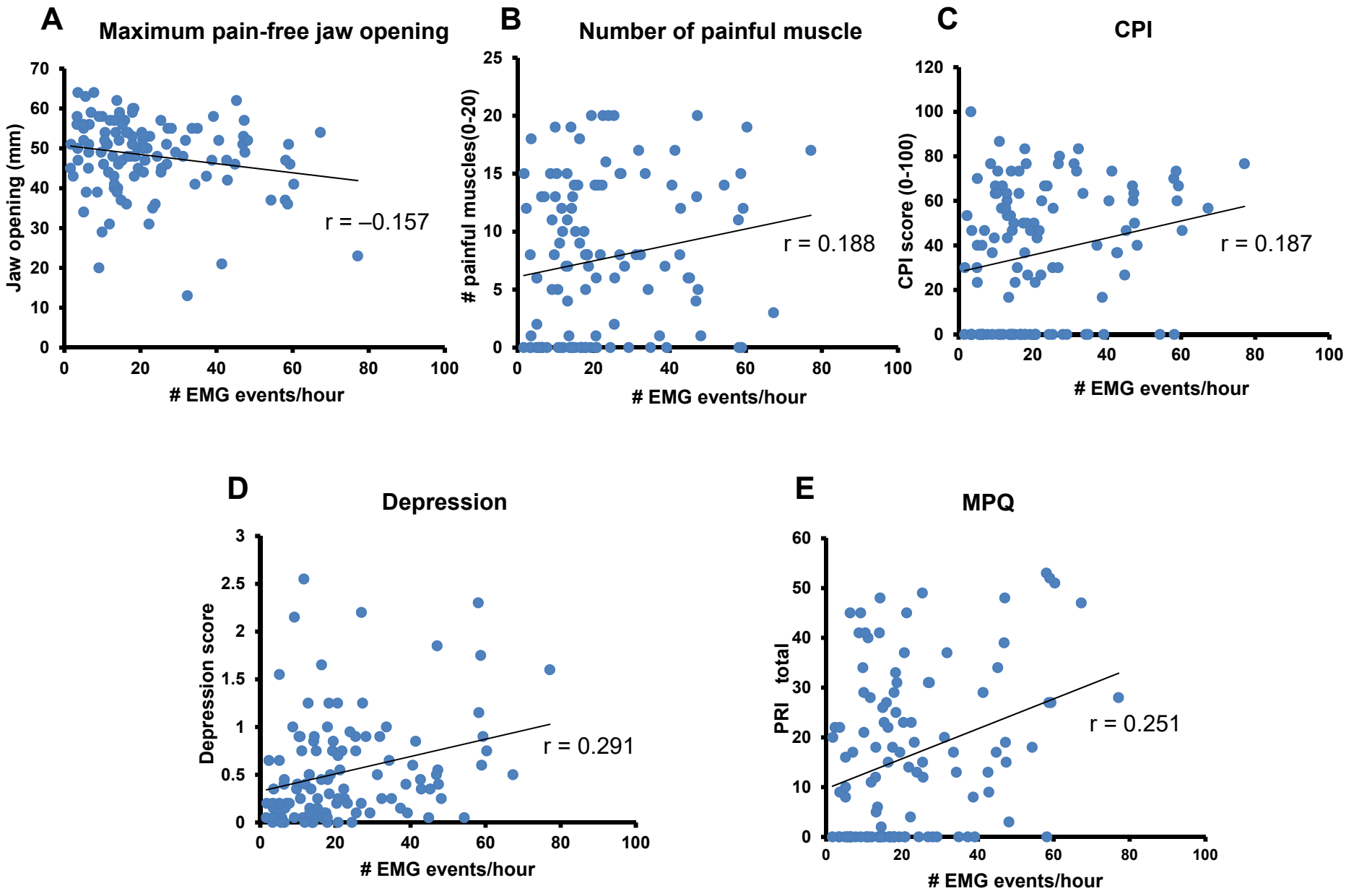

A
CV (%)
140
120
100
80
60
40
20
0
*
pTMD (+)
(n=59)
pTMD (–)
(n=56)
B
CV (%)
*
#
pTMD (+) with SB
(n=48)
pTMD (+) without SB
(n=11)
pTMD (–) with SB
(n=24)
pTMD (–) without SB
(n=32)
C
CV (%)
*
TTH
(n=30)
Healthy
(n=30)
D
CV (%)
TTH with SB
(n=18)
TTH without SB
(n=12)

Fig. 4


A
Maximum pain-free jaw opening
Jaw opening (mm)
# EMG events/hour
r = –0.157
B
Number of painful muscle
# painful muscles(0-20)
# EMG events/hour
r = 0.188
C
CPI
CPI score (0-100)
# EMG events/hour
r = 0.187
D
Depression
Depression score
# EMG events/hour
r = 0.291
E
MPQ
PRI total
# EMG events/hour
r = 0.251