Table 1S. Summary of individual evidence appraisal

JH Level	Author, year	JH Quality
Level I	*Amin et al, 2011* [40]	C
Level II	*Burgess et al, 2019* [67]	C
	Burns et al, 2019 [68]	C
	Eakman et al, 2017 [39]	C
Level III	*Balba et al, 2018* [43]	A
	Card et al, 2018 [54]	B
	Chapman et al, 2006 [53]	B
	Cunningham & Oehlert, 2018 [48]	B
	Hoot et al, 2018 [49]	B
	Hughes et al, 2013 [50]	C
	Jaoude et al, 2016 [60]	B
	Jaramilo et al, 2016 [44]	A
	Koffel et al, 2016 [45]	B
	Koffel, Amundson, & Wisdom, 2019 [61]	A
	Koffel et al, 2019 [65]	A
	Lang et al, 2014 [55]	B
	Martin et al, 2017 [42]	B
	Munds, 2017 [52]	C
	Powel et al, 2015 [63]	B
	Ruff et al, 2009 [59]	B
	Ruff et al, 2012 [58]	C
	Sangani & Baker, 2016 [41]	C
	Taylor et al, 2019 [46]	C
	Tighe et al, 2020 [64]	A
	Travaglini et al, 2019 [51]	C
	Weiner et al, 2019 [47]	C

Notes. Johns Hopkins level of evidence (JH Level) where I = RCT or meta-analysis of RCTs, II = quasi-experimental, III = non-experimental, qualitative, meta-synthesis; quality ratings (JH Quality) where A = high, B = good, C = low/major flaws.

Table 2S. Sleep disturbances & sleep disorders characteristics

Citation (year)	**Type of Sleep Disorders / Sleep Disturbance**	**Sleep Measure(s)**	**Baseline Sleep (mean ± SD);** abnormal values per threshold criteria are bolded, when applicable*
Group 1: Self-reported sleep disturbance			
Balba et al, 2019 [43]	Self-reported insomnia symptoms	ISI, FOSQ-10	ISI all subjects: **15.11 ± 6.32**[†] ISI neither group: 13.43 ± 6.08[†] ISI TBI group: 14.51 ± 5.62[†] ISI PTSD group: **19.23 ± 5.13**[†] ISI TBI+PTSD group: **19.71 ± 4.34**[†] FOSQ-10 all subjects: 14.12 ± 3.74[†] FOSQ-10 neither group: 15.40 ± 3.23[†] FOSQ-10 TBI group: 14.57 ± 3.67[†] FOSQ-10 PTSD group: 11.51 ± 3.04[†] FOSQ-10 TBI+PTSD group: 11.47 ± 3.47[†]
Burgess et al, 2019 [67]	Self-reported sleep quality and disturbances	PSQI, ISI, wrist actigraphy, and DLMO	PSQI: **7.72 ± 5.10** ISI: 8.56 ± 5.28 Actigraphy Sleep Efficiency (%): 87 ± 5.2 DLMO (hour: minutes): 19:58 ± 1.58
Burns et al, 2019 [68]	Self-reported sleep quality	Single item: "Last night, your sleep quality was. . .?" Likert, 5-points: 1 (very poor), 2 (poor), 3 (fair), 4 (good), and 5 (very good).	Single item on sleep quality: 3.03 ± 0.55 PSQI: **8.14 ± 5.29** (email communication, April 2020)
Chapman et al, 2006 [53]	Self-reported sleep quality and disturbances	PSQI	PSQI global score: **11.63 ± 4.64.** **85% (n=169) reported PSQI global scores > 5 (indicates poor sleep)**. 35.8% (n=72) were taking prescribed sleep medications.
Eakmen et al, 2017 [39]	Self-reported difficulty with sleep quality	PROMIS-Sleep Disturbance – 8 items, and PSQI-A	PROMIS-Sleep Disturbance = 59.54 (3.7)[§], PSQI-A = 7.36 (5.36)[§]
Hoot et al, 2018 [49]	Self-reported sleep quality and disturbances	PSQI	Data are: median (range) PSQI TBI group: **11** (1-21) PSQI no TBI group: **8** (1-18)

Citation (year)	**Type of Sleep Disorders / Sleep Disturbance**	**Sleep Measure(s)**	**Baseline Sleep (mean ± SD);** abnormal values per threshold criteria are bolded, when applicable*
Group 1: Self-reported sleep disturbance (cont.)			
Hughes et al, 2013 [50]	Self-reported sleep quality and disturbances & self-reported insomnia symptoms	PSQI, ISI	PSQI: **7.5** 58% had PSQI > 5 Mean ISI: **8.5** 50% had at least mild insomnia symptoms
Koffel et al, 2016 [45]	Self-reported sleep disturbance	Selected items from PROMIS Sleep Disturbance and Fatigue scales, (*not scored per PROMIS system; rather, total score ranged from 4 to 20, with higher scores indicating greater levels of sleep impairment and fatigue*) PHQ-9: 2 sleep complaints items, and SF-36: vitality scale *(transformed score range: 0-100; lower scores: reduced vitality)*	PROMIS-Sleep Disturbance: 12.7 ± 4.3[§] PROMIS Fatigue: 12.4 ± 4.3[§] PHQ-9 sleep disturbance item: 1.4 ± 0.8[§] PHQ-9 fatigue item: 1.4 ± 0.7878[§] SF-36 Vitality scale: 40.6 ± 22.65[§]
Koffel et al, 2019 [65]	Self-reported sleep disturbance	PROMIS-Sleep Disturbance – 8 items	PROMIS-Sleep Disturbance (severe sleep dist. group defined as baseline PSQI≥30): 33.5 ± 2.8 PROMIS-Sleep Disturbance (no severe sleep dist. group; PSQI<30): 20.5 ± 6.2
Munds, 2017 [52]	Self-reported sleep disturbance	ISDI: Daytime Disturbances subscale	ISDI: 8.4 ± 4.17 (range 6-10)
Powel et al, 2015 [63]	Self-reported sleep quality and disturbances	PSQI	PSQI: **9.26 ± 4.77**
Ruff et al, 2009 [59]	Self-reported sleep impairment	Two questions: (1) "Is your sleep impaired due to nightmares or for any other reason?" and (2) "When you awake from sleep at the end of your sleeping period, do you feel rested?"	94.2% (n=69) reported unrestful sleep with nocturnal arousals associated with nightmares, agitated sleep, or both.
Ruff et al, 2012 [58]	Self-reported excessive daytime sleepiness	ESS	ESS: **16 ± 0.3**
Sangani & Baker, 2016 [41]	Self-reported sleep quality and disturbances	PSQI: Sleep Disturbance component only	**Only 22% of participants reported global PSQI scores < 5**
Tighe et al, 2020 [64]	Self-reported sleep disturbance	PHQ-8 single item: how often in the preceding two weeks bothered by "trouble falling or staying asleep, or sleeping too much".	PHQ-8 sleep disturbance item: 1.41 ± 1.18

Citation (year)	**Type of Sleep Disorders / Sleep Disturbance**	**Sleep Measure(s) (*threshold criteria, if applicable*)**	**Baseline Sleep (mean ± SD);** abnormal values per threshold criteria are bolded, when applicable*
Group 2: Diagnosed sleep disorder			
Amin et al, 2011 [40]	Sleep Disordered Breathing (SDB)	Full-night diagnostic PSG. SDB events defined as: apneas =↓ airflow to <20% of waking levels for at least 10 seconds, and hypopneas = ↓ airflow to <50% of waking levels with arousal, and PSQI.	AHI: **19.95 ± 25.35**[§] SE: 77.02 ± 17.18[§] PSQI: **11.9 ± 4.2**[§]
Card et al, 2018 [54]	Obstructive sleep apnea	ICD-9 OSA diagnose codes from EHR	10.6% (n = 94,296) had OSA diagnosis
Cunningham & Oehlert, 2018 [48]	Obstructive sleep apnea, insomnia, circadian rhythm disruption, etc.	ICD-9 Codes: 327.20, 327.21, 327.22, 327.23, 327.24, 327.25, 327.26, 327.27, 327.29, 780.51, 780.53, 780.55, 780.56, 780.57, 780.58, 307.40, 307.41, 307.42, 307.43, 307.44, 307.45, 307.46, 307.47, 307.48, 307.49, 780.50, 780.52, 780.54, 780.59[†]	Diagnoses were: 35.65% (n=1,953) SDB, 21.65% (n=1,186) insomnia or other sleep/circadian rhythm disorder, 42.7% (n=2,339) with both SDB and insomnia or other.
Jaounde et al, 2016 [60]	Obstructive sleep apnea	In laboratory diagnostic PSG: AHI was ≥ 5/h	Chronic opiate group proportion of mild, moderate, and severe OSA: 22%, 34%, and 44% versus 21%, 28%, and 40% respectively in control group.
Jaramillo et al, 2016 [44]	Insomnia Disorder	ICD-9-CM Codes: 780.5 and 786.09	Insomnia dx. freq. at baseline in headache group (n=5,264): 21.88% (n=1,152)
Koffel, Amundson, & Wisdom,2019[61]	Insomnia Disorder	ISI	Mean ISI: **19**
Lang et al, 2014 [55]	Insomnia Disorder	ISI > 15 for insomnia diagnosis	Insomnia frequency: 73%. ISI: **18.05 ± 6.6**
Martin et al, 2017 [42]	Insomnia Disorder	Survey addressing ICSD-2 diagnostic criteria	Insomnia prevalence: 51.5% (n=345). Overall sleep quality (n=670): very good (13.7%), fairly good (44.2%), fairly bad (34.8%), and very bad (7.4%). Overall sleep difficulty (n=670): difficulty staying asleep (67.5%), falling asleep (52.1%), and early awakenings (62%).

	7	9.5% had at least one sleep complaint.

Citation (year)	Type of Sleep Disorders / Sleep Disturbance	Sleep Measure(s) (*threshold criteria, if applicable*)	**Baseline Sleep (mean ± SD);** abnormal values per threshold criteria are bolded, when applicable*
Group 2: Diagnosed sleep disorder (cont.)			
Travaglini et al, 2019 [51]	Subthreshold Insomnia Disorder (defined as ISI score ≥8)	ISI: for eligibility screening only, and PSQI	PSQI: **13.86 ± 2.68** ISI: **18.67 ± 4.24**
Taylor et al, 2019 [46]	Obstructive sleep apnea	OSA diagnoses (ICD-9 & ICD-10 codes†)	Not reported
Weiner et al, 2019 [47]	Insomnia disorder (defined as ISI score > 11)	ISI	Insomnia prevalence: 63.8%

Notes. † = Data comes directly from the author or subsequent publication assessing the same sample. § = pooled estimate (data was pooled where there were no significant differences between studied groups). 36-Item short-form health survey (SF-36), apnea-hypopnea index (AHI), dim light melatonin onset (DLMO), electronic health record (EHR), Epworth sleepiness scale (ESS), functional outcomes of sleep questionnaire (FOSQ-10), Iowa sleep disturbances inventory (ISDI), insomnia severity index (ISI), international classification of diseases - 9th edition (ICD-9), international classification of diseases - 10th edition (ICD-10) international classification of sleep disorders, 2nd edition (ICSD-2), obstructive sleep apnea (OSA), patient health questionnaire-9 (PHQ-9), patient-reported outcomes measurement information system (PROMIS), Pittsburgh sleep quality index (PSQI), Pittsburgh sleep quality index addendum for PTSD (PSQI-A), polysomnography (PSG), standard deviation (SD), sleep disordered breathing (SDB), and sleep efficiency (SE). * = Threshold criteria, when applicable are: AHI (≥ 15, but < 30 per hour: moderate OSA), ESS *(≥ 11: excessive daytime sleepiness),* FOSQ-10 (range: 5-20; higher scores: better functional status), ISI (≥ 15: clinical insomnia), PROMIS-Sleep Disturbance – 8 items (*T-scores range: 28–76.5; mean: 50; higher scores: more sleep disturbances*), PSQI *(≥ 5: "poor" sleeper*), and PSQI-A (*range: 0-21; higher scores: greater more PTSD-related sleep disturbances*)

Table 3S. Pain characteristics

Citation (year)	Pain Primary Outcome (Yes/No)	Type of Pain	Duration of Pain	Pain Measure(s)	Baseline Pain (mean ± SD)
Amin et al, 2011 [40]	Yes	Chronic pain (involving at least two body regions)	> 6 months	VAS rated 0–10	5.11 ± 2.77
Balba et al, 2019 [43]	Yes	Chronic headache	NR	PROMIS Global Health Survey, item 7: a 11-point Likert scale for overall pain level (0 = no pain to 10 = worst pain)	All subjects: 4.07 ± 2.48[†] Neither group: 3.44 ± 2.27[†] TBI group: 4.20 ± 2.46[†] PTSD group: 5.00 ± 2.58[†] TBI+PTSD group: 5.89 ± 1.98[†]
Burgess et al, 2019 [67]	Yes	Chronic low back pain	> 6 months	PROMIS Pain Intensity, PROMIS Pain Behavior, PROMIS Pain Interference, and PROMIS Physical Function, and pain sensitivity (heat & ischemia stimulus)	PROMIS Pain Intensity: 48.84 ± 6.30 PROMIS Pain Behavior: 56.67 ± 6.49 PROMIS Pain Interference: 56.39 ± 8.33 PROMIS Physical Function: 44.21 ± 8.66 Ischemic threshold, sec 81.48 ± 119.8 Ischemic tolerance, sec 187.88 ± 160.13 Thermal threshold, ℃ 42.95 ± 3.68 Thermal tolerance, ℃ 47.09 ± 1.64
Burns et al, 2019 [68]	Yes	Chronic low back pain	> 6 months	Two items: pain intensity ("How intense was your pain?") and interference ("To what degree did your pain interfere with you being physically active?"); 9-point scale (0 = not at all to 8 = extremely).	Pain Intensity: 2.5 ± 1.28 Pain Interference: 1.99 ± 1.20

Citation (year)	Pain Primary Outcome (Yes/No)	Type of Pain	Duration of Pain	Pain Measure(s)	Baseline Pain (mean ± SD)
Card et al, 2018 [54]	Yes	Current pain	NR	Numeric scale rated 0-10 (categorized as: mild if 0-3, moderate/severe if 4-10)	32% (n= 274,632) reported pain of moderate/severe intensity
Chapman et al, 2006 [53]	Yes	Chronic Pain (musculoskeletal = 61%, neuropathic = 30%, visceral = 2.5, other [e.g., headache] = 6.5%)	NR	The Multidimensional Pain Inventory (MPI): pain severity, pain interference, and general activity level scales only	Severity: 4.48 ± 1.27 Interference: 4.37 ± 1.27 General activity level: 1.92 ± 0.92
Cunningham & Oehlert, 2018 [48]	Yes	Current pain	NR	The Millon Behavioral Medicine Diagnostic (MBMD): Pain sensitivity scale	Average MBMD score (SEM): for those with sleep disorder (n=5,478) = 76.3 ± .31 versus those without sleep disorder (n = 3,925) = 69.8 ± .40
Eakmen et al, 2017 [39]	Yes	Current pain	NR	PROMIS-PI (pain interference)	PROMIS-PI = 59.12 ± 9
Hoot et al, 2018 [49]	Yes	Current pain	NR	EuroQol group 5 dimension 5 level (EQ-5D-5L) scale (5-point scale; rate pain from none to extreme) and the TBI Quality of Life (TBI-QoL) pain interference scale (10 items on a 5-point ordinal scale; higher score: greater interference)	Pain interference, TBI exposed group = 24.24 ± 10.55, No TBI group = 17.43 ± 8.17
Hughes et al, 2013 [50]	No	Current pain†	NR	Geriatric Pain Measure (GPM): pain intensity subscale; 7 items†	NR
Jaoude et al, 2016 [60]	Yes	Chronic pain (causes of opiate prescription: musculoskeletal disorders = 83%, neuropathies=11%)	≥ 6 months	Numerical Categorical Scale (0 to 10 points)	Pain intensity: opiate group = 2.5 ± 1.4 versus 1.6 ± 1.1 among no opiate group (control)

Citation (year)	Pain Primary Outcome (Yes/No)	Type of Pain	Duration of Pain	Pain Measure(s)	Baseline Pain (mean ± SD)
Jaramillo et al, 2016 [44]	Yes	Chronic posttraumatic headaches (PTHA) & PTHA Persistent headache	PTHA headaches: > 3 months. Persistent PTHA: from 1-4 years.	ICD-9-CM codes; 339, 346, 784, 307.81. PTHA is persistent when diagnosed each year for 4 consecutive years – FY08-FY11.	Not reported
Koffel et al, 2016 [45]	Yes	Chronic musculoskeletal pain	≥ 3 months	Brief Pain Inventory (BPI), SF-36 Bodily Pain scale, and PROMIS-PI (pain intensity & pain interference)	BPI total: 5.2 ± 1.8 SF-36 bodily pain: 34.8 ± 16.8 PROMIS-PI:.11.35 ± 4.25
Koffel, Amundson, & Wisdom, 2019 [61]	Yes	Chronic pain	NR	PEG scale (which assesses pain intensity [P], interference with enjoyment of life [E], and interference with general activity [E]; range 0-10)	Mean PEG score: 6
Koffel et al, 2019 [65]	Yes	Chronic back pain or hip or knee OA pain of moderate to severe intensity despite analgesic use	≥ 6 months	Brief Pain Inventory (BPI) – Short Form (rated on 0-10 scales)	BPI Interference Scale (severe sleep dist. group): 6.5 ± 1.6 BPI Severity Scale (severe sleep dist. group): 5.9 ± 1.4 BPI Interference Scale (no severe sleep dist. group): 5.0 ± 1.8 BPI Severity Scale (no severe sleep dist. group): 5.2 ± 1.3
Lang et al, 2014 [55]	Yes	Current pain	Not reported. However, approx. 90% of subjects experienced pain other than everyday types of pain.	Brief Pain Inventory (BPI) – Short Form (rated on 0-10 scales)	BPI pain severity: 4.22 ± 2.26 BPI pain interference: 4.60 ± 2.78

Citation (year)	Pain Primary Outcome (Yes/No)	Type of Pain	Duration of Pain	Pain Measure(s)	Baseline Pain (mean ± SD)
Martin et al, 2017 [42]	No	Current pain	NR	Single question: "During the past month, did any of these issues affect your sleep?" Pain was one of the items for which they could circle yes or no.†	NR
Munds, 2017 [52]	Yes	Chronic pain	> 3 months (self-reported) †	Chronic Pain Grade Questionnaire (CPGC); disability subscale	CPGC disability scale: 7.3 ± 7.02 (range 6-10)
Powel et al, 2015 [63]	Yes	Current pain & Chronic pain	Current pain (over the last 30 days). Of note, 38% (n=65) of the sample had chronic pain (>3 mo.)	McGill Short Form Pain Questionnaire visual analogue scale (VAS) of pain only (score range: 0-100)	McGill VAS: 30.07 ± 25.43
Ruff et al, 2009 [59]	Yes	Chronic posttraumatic headache pain (40.54 % tension-like, 18.92 % migraine-like, and 40.54 % mixed-type)	NR	Numerical pain rating scale (0 to 10 points) & number of headaches per month	Headache frequency = 12.4 ± 0.94; 95% had >4 headache episodes/month; 42% had >10 headache episodes/month 14% had daily headaches Headache intensity = 7.28 ± 0.27
Ruff et al, 2012 [58]	Yes	Chronic posttraumatic headache pain (38% tension-like, 21% migraine-like, and 40% mixed-type)	NR	Numerical pain rating scale (0 to 10 points) & number of headaches per month	Headache frequency = 13.3 ± 0.71 Headache intensity = 7.32 ± 0.17
Sangani & Baker, 2016 [41]	Yes	Chronic Pain (Rheumatoid arthritis)	NR	RAPID 3 form (which includes a VAS pain severity question; range for pain subscale: 0-10)	VAS pain severity: 5.82 ± 2.90†

Citation (year)	Pain Primary Outcome (Yes/No)	Type of Pain	Duration of Pain	Pain Measure(s)	Baseline Pain (mean ± SD)
Taylor et al, 2019 [46]	Yes	Low Back Pain	NR	Low back pain diagnosis (ICD-9 & ICD-10 codes†)	NR
Tighe et al, 2020 [64]	Yes	Knee pain consistent with knee OA	NR	Pain severity scale (rate: 0–10) and Pain Catastrophizing Scale (PCS).	Pain severity: not reported. PCS: 19.11 ± 12.35
Travaglini et al, 2019 [51]	No	Current pain	Over 40% of participants reported a possible chronic pain condition such as osteoarthritis, rheumatoid arthritis, bone or joint problems†	Pain Numeric Rating Scale (PNRS; score range: 0-10) & one pain interference item from Short Form 12 Health Survey (SF-12; rated on a 5-point scale, "not at all" to "extremely")	PNRS: 5.29 ± 2.62 71.9% reported moderate-to-severe pain (PNRS≥4) SF-12: 3.12 ± 1.28
Weiner et al, 2019 [47]	Yes	Chronic low back pain (CLBP)	≥ 6 months	0 to 10 scale, last 7-day average and worst pain (severity); Roland Morris questionnaire (back pain disability)	Pain severity (average past week): 6.15 ± 1.96 (2-10, range) Pain severity (worst past week): 8.36 ± 1.79 (3-10, range) Pain duration (months): 224.7 ± 197.8 (3.0-632.7, range) Roland Morris: 14.25 ± 4.52 (3-22, range)

Notes. † = Data comes directly from the author or subsequent publication. Not reported (NR), osteoarthritis (OA), patient-reported outcomes measurement information system (PROMIS), and standard error of measurement (SEM).

Table 4S. Definitions of sleep disturbance across selected studies

Citation (year)	Sleep Disturbance Definition Used in The Article	Sleep Disturbance Measure(s)
Balba et al, 2018 [43]	No definition stated. However, sleep disturbances are used as synonyms for sleep disorders such insomnia, hypersomnia, OSA, and circadian rhythm disorders.	ISI, FOSQ-10
Burgess et al, 2019 [67]	NR	PSQI, ISI, and wrist actigraphy
Burns et al, 2019 [68]	NR	Single item on sleep quality
Chapman et al, 2006 [53]	NR	PSQI
Eakmen et al, 2017[39]	No definition stated. However, sleep disturbance is used as a synonym of insomnia symptoms (difficulty falling or staying asleep), but also includes dissatisfaction with sleep quality and duration, and incorporates disruptive nocturnal behaviors (e.g., nightmares).	PROMIS-SD, PSQI-A
Hoot et al, 2018 [49]	NR	PSQI
Hughes et al, 2013 [49]	NR	PSQI
Munds, 2017 [52]	No definition stated. Sleep disturbances are discussed in the context of insomnia. Of note, the Daytime Disturbances ISDI subscale used to assess sleep disturbances in the study has 2 additional subscales: fatigue & nonrestorative sleep subscales.	Iowa Sleep Disturbances Inventory (ISDI): Daytime Disturbances subscale
Koffel et al, 2016 [45]	Two independent but related lower order dimensions: “insomnia (difficulties falling and staying asleep) and lassitude (fatigue and sleepiness)”	sleep disturbance and fatigue PHQ-9 items, PROMIS-SD, PROMIS-Fatigue
Koffel et al, 2019 [65]	NR	PROMIS-SD
Powell et al, 2015 [63]	NR	PSQI
Ruff et al, 2009 [59]	No definition stated. However, authors talk about “impaired sleep” which is manifested as being unrestful and in the presence of nightmares	“Is your sleep impaired due to nightmares or for any other reason?” & “When you awake from sleep at the end of your sleeping period, do you feel rested?”
Ruff et al, 2012 [58]	NR	ESS

Citation (year)	Sleep Disturbance Definition Used in The Article	Sleep Disturbance Measure(s)
Sangani & Baker, 2016 [41]	NR	PSQI: Sleep Disturbance component only
Tighe et al, 2020 [64]	No definition stated, but operationalized by assessing "trouble falling or staying asleep, or sleeping too much"	PHQ-8 sleep disturbance single item

Notes. Epworth sleepiness scale (ESS), functional outcomes of sleep questionnaire (FOSQ-10), Iowa sleep disturbances inventory (ISDI), insomnia severity index (ISI), not reported (NR), patient health questionnaire-9 (PHQ-9), Pittsburgh sleep quality index (PSQI).

Table 5S. Detailed table of main findings on the influence of sleep disturbance and sleep disorders on pain outcomes among veterans

Citation (year)	Baseline adjusted variables	Independent (sleep) variable(s)	Dependent (self-reported pain) outcome(s)	Results: Poor or worsened sleep	Results: Good or improved sleep
Group 1: Observational Studies (without treating pain or sleep)					
Balba et al, 2018 [43]	n/a	Self-reported insomnia symptoms	Pain severity	pain severity across all studiedgroups: TBI only [*r* = .37]**, PTSD only [*r* = .22]*, TBI + PTSD [*r* = .30]*, Neither [*r* = .293]***	NR
Card et al, 2018 [54]	Age, sex, race, BMI, smoking status, and mental health diagnoses (substance use, PTSD, depression, and anxiety)	OSA diagnosis	Pain intensity	likelihood of reporting moderate/severe pain intensity (aOR = 1.28; 95% CI 1.27-1.30)	NR
Chapman et al, 2006 [53]	Analysis #1: Opioid prescription, baseline pain, 2-month sleep med. prescription, and depressive symptoms	Self-reported sleep quality and sleep disturbance	Pain severity, Pain interference, and General activity level	Did not predict any of the studied pain outcomes	NR
	Analysis #2: Opioid prescription, baseline pain, sleep quality and disturbance, and depressive symptoms	Sleep medication prescription	Pain severity, Pain interference, and General activity level	NR	Taking sleep medications were not associated with pain outcomes.
Cunningham & Oehlert, 2018 [48]	n/a	Sleep disorder diagnoses (see list of codes on Table 2S)	Pain sensitivity	pain sensitivity*** (with *vs.* without diagnoses; t=12.9)	NR

Citation (year)	Baseline adjusted variables	Independent (sleep) variable(s)	Dependent (self-reported pain) outcome(s)	Results: Poor or worsened sleep	Results: Good or improved sleep
Group 1: Observational Studies (without treating pain or sleep) (cont.)					
Hoot et al, 2018 [49]	Age, site, time since index injury, depression, PTSD, anxiety, combat exposure, combat duration, number of controlled and uncontrolled blast exposures	Self-reported sleep quality and sleep disturbance	Pain intensity & Pain interference	pain interference (β = 0.41)* and pain intensity (β = 0.05)*	NR
Hughes et al, 2013 [50]	Analysis #1: n/a	Self-reported sleep quality and sleep disturbance	Pain intensity	pain intensity**	NR
	Analysis #2: n/a	Self-reported insomnia symptoms	Pain intensity	pain intensity***	NR
Jaramillo et al, 2016 [44]	Demographic and military characteristics, TBI, PTSD, and/or postconcussive symptoms.	Insomnia disorder diagnosis	Posttraumatic headaches (PTHA) prevalence & PTHA persistence	Insomnia diagnosis at baseline was associated with: headache prevalence (aOR: 1.97 [1.81-2.15]) *** headache persistence (aOR: 1.19 [1.02-1.39])***	NR
Koffel et al, 2016 [45]	Baseline covariates (education, income, pain sites, duration of pain, medical comorbidities, and treatment group) and depression & anxiety symptoms.	Changes in self-reported sleep disturbance (insomnia symptoms [difficulties falling and staying asleep] and lassitude [fatigue])	Pain (intensity & interference, loaded as a single factor after EFA)	NR	Improvements in sleep disturbance symptoms from baseline to 3 months predicted pain (intensity & interference) (β = .29) at 12 months***

Citation (year)	Baseline adjusted variables	Independent (sleep) variable(s)	Dependent (self-reported pain) outcome(s)	Results: Poor or worsened sleep	Results: Good or improved sleep
Group 1: Observational Studies (without treating pain or sleep) (cont.)					
Koffel et al, 2019 [65]	Baseline BPI values and treatment group assignment	Self-reported sleep disturbance	Pain severity & Pain interference	pain interference (6.5 vs 5.0)*** and pain severity (5.9 vs 5.2)*** on severe baseline sleep disturbance group, versus those without severe sleep disturbance. improvement in pain interference (β = 0.058)*** and pain severity (β = 0.026)*	NR
Koffel, Amundson, & Wisdom, 2019 [61]	n/a	n/a	Pain perception	NR	Improvements in sleep "enhanced functionality [*and quality of life*] in the context of chronic pain"
Lang et al, 2014 [55]	Service connection (mediation models only)	Self-reported insomnia symptoms	Pain severity & Pain interference	pain severity (Person's r =.53;β = 0.18)**; pain interference (Person's r =.57; β = 0.23)** Partially mediated relationship between PTSD symptoms and pain severity (β = 0.12)** and PTSD symptoms and pain interference (β = 0.13)**	NR
Martin et al, 2017 [42]	n/a	Insomnia disorder diagnosis	Pain interference with sleep	frequency of pain interference on sleep was reported among women veterans with insomnia diagnosis than those without insomnia (62.7% vs. 36.9%) ***	NR
Munds, 2017 [52]	None	Self-reported sleep disturbance	Pain-related disability	Sleep disturbance did not moderate the relationship between PTSD and disability due to chronic pain	NR

Citation (year)	Baseline adjusted variables	Independent (sleep) variable(s)	Dependent (self-reported pain) outcome(s)	Results: Poor or worsened sleep	Results: Good or improved sleep
Group 1: Observational Studies (without treating pain or sleep) (cont.)					
Powel et al, 2015 [63]	PTSD severity, current mood disorder diagnosis, current anxiety disorder diagnosis, and alcohol use.	Self-reported sleep quality and sleep disturbance	Pain severity in the last 30 days	pain severity (β = .28) ** among the total sample (presumed chronic pain), but not among the subset (n=65) with confirmed chronic pain	NR
Sangani & Baker, 2016 [41]	n/a	Self-reported sleep disturbance	Pain intensity	pain intensity (Spearman's ρ = 0.44)*	NR
Taylor et al, 2019 [46]	Age, race, sex, combat exposure, Charlson comorbidity index, marital status, and combat exposure[†]	OSA diagnosis	Low back pain diagnosis	odds of LBP diagnosis (aOR 8.99 [95% CI: 7.07, 11.35]); OSA diagnosis mediated the effect of PTSD on risk of LBP diagnosis, explaining 25% of the risk (95% CI, 19.6%, 31.1%)	NR
Tighe et al, 2020 [64]	Sociodemographic and clinical characteristics (e.g., age, BMI, race, education, income, depression and anxiety history, radiographic evidence of OA, and opioid use)	Self-reported sleep disturbance	Pain severity & Pain catastrophizing.	Frequency of sleep disturbance was associated with: pain severity (β = 3.58)*** and pain catastrophizing (β = 2.47)***	NR
Travaglini et al, 2019 [51]	n/a	Self-reported sleep quality and sleep disturbance	Pain intensity & Pain interference	pain interference (Pearson's r = .32)*, but not pain intensity (r = .20)	NR
Weiner et al, 2019 [47]	n/a	Insomnia disorder diagnosis	Pain disability & Pain severity	Back pain disability*, but not pain severity	NR

Citation (year)	Baseline adjusted variables	Independent (sleep) variable(s)	Dependent (self-reported pain) outcome(s)	Results: Poor or worsened sleep	Results: Good or improved sleep
Group 2: Experimental, quasi-Experimental Studies, or observational studies with treatment of pain or sleep.					
Amin et al, 2011 [40]	n/a	Nasal CPAP (treatment) vs. sham CPAP (control)	Pain severity	NR	Treatment of SDB with CPAP significantly ↓ pain intensity (34%; SMD = 2.14) ***
Burgess et al, 2019 [67]	n/a	Morning bright light therapy	Pain intensity, pain behavior, pain interference, pain sensitivity (objectively measured), and physical function	NR	↓ pain intensity* (48.84 ± 6.30 vs. 47.02 ± 7.77), ↓ pain behavior* (56.67 ± 6.49 vs. 54.63 ± 8.09), and ↓ pain sensitivity*(thermal pain threshold: 42.95 ± 3.68 to 43.72 ± 3.11) from baseline to 13 days post-treatment.
Burns et al, 2019 [68]	The three study epochs: baseline, bright light treatment, and follow-up	Morning bright light therapy	Pain intensity, Pain intensity volatility, and Pain interference	NR	↓ mean pain intensity*** during post-treatment (β = –0.20, SE = 0.04) and follow-up (β = –0.21, SE = 0.04) compared with baseline. ↓ pain intensity volatility*** during post-treatment (β = –0.90, SE = 0.13) and follow-up (β = –0.83, SE = 0.13) compared with baseline.
Eakmen et al, 2017 [39]	n/a	Multicomponent CBT-I	Pain interference	NR	↓ pain interference (Cohen's *d* = 0.45) from baseline to post-treatment

Citation (year)	Baseline adjusted variables	Independent (sleep) variable(s)	Dependent (self-reported pain) outcome(s)	Results: Poor or worsened sleep	Results: Good or improved sleep
Group 2: Experimental, quasi-Experimental Studies, or observational studies with treatment of pain or sleep. (cont.)					
Jaoude et al, 2016 [60]	n/a	Nasal CPAP	Pain intensity	Non-adherent participants reported pain intensity at baseline* and 12 months (p=0.05)	Pain intensity did not significantly decrease from baseline to follow-up.
Ruff et al, 2009 [59]	n/a	Taking Prazosin (yes/no)	Headache pain severity and frequency	NR	↓ pain severity and frequency (baseline to 9-wk posttreatment)*** ↓ pain severity and frequency among veterans who completed dosing of prazosin (9-wk posttreatment)*** ↓ pain severity and frequency among those taking prazosin (6-month follow-up)***
Ruff et al, 2012 [58]	n/a	Daytime Sleepiness	Headache pain severity and frequency	Greater daytime sleepiness was associated with: HA pain intensity at 9-wk (Pearson's r = 0.53)***, and 6-mo (Pearson's r = 0.66)*** HA pain frequency at 9-wk (Pearson's r = 0.27)*, and 6-mo (Pearson's r = 0.67)***	Differences on daytime sleepiness from endpoint to baseline (ϟ) were associated with: ↓ HA pain intensity at 9-wk (Pearson's r = 0.57)***, and 6-mo (Pearson's r = 0.58)*** ↓ HA pain frequency at 9-wk (Pearson's r = 0.28)*, and 6-mo (Pearson's r = 0.26)*

*Note*s. * = significant (p < 0.05); ** = significant (p < 0.01); *** = significant (p < 0.001); † = Data from some of those columns come directly from the author or subsequent publication. Adjusted odds ratio (AOR), brief pain inventory (BPI), continuous positive airway

pressure (CPAP), exploratory factor analysis (EFA), fiscal year (FY), headache (HA), low back pain (LBP), none reported (NR), obstructive sleep apnea (OSA), osteoarthritis (OA), post-traumatic stress disorder (PTSD), sleep disordered breathing (SBD), standardized mean difference (SMD), traumatic brain injury (TBI).

Appendix 1 - Literature Search Report

Note: In each database, searches grouping together authorized subject headings and text keywords relating to sleep disorders were merged with searches identifying veterans as research subjects or studies authored by researchers with a Veterans' Administration affiliation. Author affiliation was used as part of the search strategy because VA-affiliated research is likely to use the population of interest whether or not it was specifically identified in the abstract or metadata associated with an article. No date limit or language restriction was applied to any of the searched databases. Publications in foreign languages were translated into English by Google Translate.

PubMed

3/18/2020

#	Search Statement	Results	Annotation
1	sleep disorder* OR "sleep disorders, intrinsic"[Mesh] OR sleep OR insomnia OR insomni*[tiab] OR "sleep apnea, obstructive"[Mesh] OR sleep apn* OR obstructive sleep apn* OR hypersomnia*[tiab] OR "insomnia severity index"[tiab] OR "Multiple Sleep Latency Tests"[tiab] OR "Epworth sleepiness scale"[tiab] OR "STOP-Bang"[tiab] OR "STOPBANG"[tiab]	218100	
2	pain OR "Pain"[mesh] OR chronic pain OR pain tolerance[tiab] OR pain threshold[tiab] OR pain intensity[tiab]	818327	
3	"Military Personnel"[Mesh] OR "Veterans"[Mesh] OR "Veterans Health"[Mesh] OR Veteran*[tiab] OR "veteran populations"[tiab] OR veteran[ad] OR veterans[ad] OR VA Med [ad] OR VA medical[ad] OR VA hospital[ad] OR VA Health[ad] OR VA Connecticut[ad] OR "prime center"[All Fields] OR "Department of Veterans Affairs"[tiab] OR "hospitalized veterans"[tiab] OR "VA hospital"[tiab] OR veteran*[Other Term] OR "US Department of Veterans Affairs"[Grant Number] OR "Department of veterans affairs"[ALL FIELDS] OR "veterans health administration"[All fields]	213969	
4	1 and 2 and 3	**470**	

EMBASE

3/18/2020

#	Search Statement	Results	Annotation
1	‘sleep’ OR 'sleep disorder' OR 'sleep disordered breathing' OR 'sleep apnea':ti,ab OR 'hypersomnia' OR 'insomnia' OR 'insomnia severity index' OR 'somnolence' OR 'epworth sleepiness scale' OR 'sleep latency' OR 'Multiple Sleep Latency Tests' OR 'Epworth sleepiness scale' OR 'STOP-Bang' OR 'STOPBANG'	405,515	
2	pain OR 'pain threshold' OR 'pain tolerance':ti,ab OR 'chronic pain' OR 'pain intensity'	1,300,777	
3	'soldier'/exp OR 'veteran'/exp OR 'veterans health':ti,ab OR 'veterans health':ff OR 'veterans administration':ff OR 'veterans hospital':ff OR ‘veterans affairs’:ff	163,763	
4	[embase]/lim	25,619,526	
5	([embase]/lim AND [medline]/lim)	16,039,544	
6	1 and 2 and 3 and 4	831	
7	6 not 5	**307**	

PsycINFO

3/18/2020

#	Search Statement	Results	Annotation
1	SU('sleep' OR 'sleep disorders' OR 'sleep apnea' OR 'hypersomnia' OR 'insomnia') OR AB('sleep' OR 'apnea' OR insomnia OR 'insomnia severity index' OR 'sleep disordered breathing' OR 'somnolence' OR 'epworth sleepiness scale' OR 'sleep latency' OR 'Multiple Sleep Latency Tests' OR 'Epworth sleepiness scale' OR 'STOP-Bang' OR 'STOPBANG')	81,943	
2	SU(pain OR 'pain thresholds' OR 'pain tolerance' OR 'chronic pain') OR AB(pain OR 'pain intensity')	100,256	
3	noft('veterans health' OR 'veterans health' OR 'veterans administration' OR 'veterans hospital' OR 'veterans affairs') OR (soldier* OR veteran*')	53,317	
4	1 and 2 and 3	176	Of which, 161 are journal articles & 7 are dissertation and thesis (8 book references were excluded)
5	4 AND stype.exact("Scholarly Journals" OR "Dissertations & Theses")	**168**	Used this as final sample from PsychINFO

CINAHL

3/18/2020

#	Search Statement	Results	Annotation
1	((MH "Dyssomnias+") OR (MH "Sleep Disorders+") OR (MH "Sleep Apnea Syndromes+") OR (MH "Disorders of Excessive Somnolence+") OR (MH "Insomnia+")) OR AB ('sleep' OR 'sleep disorder' OR 'sleep disordered breathing' OR 'sleep apnea' OR 'hypersomnia' OR 'insomnia' OR 'insomnia severity index' OR 'somnolence' OR 'epworth sleepiness scale' OR 'sleep latency' OR 'Multiple Sleep Latency Tests' OR 'Epworth sleepiness scale' OR 'STOP-Bang' OR 'STOPBANG')	71,996	
2	(MH “pain+” OR MH “chronic pain” OR AB('pain threshold' OR 'pain tolerance' OR 'pain intensity' OR pain))	318,536	
3	(AF (veteran* OR military OR 'veteran's administration' OR 'VA hospital") OR MW veteran* OR MW soldier* OR TX veteran*)	107,079	
4	1 and 2 and 3	323	Of which, 170 are Medline records
5	4 AND Limiters - Exclude MEDLINE records	**153**	Used this as final sample from CINAHL

SCOPUS

3/18/2020

#	Search Statement	Results	Annotation
1	TITLE-ABS-KEY ("sleep" OR "sleep disorder" OR "sleep disordered breathing" OR "sleep apnea" OR "hypersomnia" OR "insomnia")	317,332	
2	TITLE-ABS-KEY ("pain" OR "pain threshold" OR "pain tolerance" OR "chronic pain" OR "pain intensity")	1,125,188	
3	(TITLE-ABS-KEY ("soldier" OR "veteran*") OR AFFIL ("veteran*" OR "veterans health" OR "veterans health" OR "veterans administration" OR "veterans hospital" OR "veterans affairs"))	337,401	
4	(LIMIT-TO (DOCTYPE , "ar"))		
5	1 and 2 and 3	885	Of which, 676 are articles (others are reviews, letters to editor, book chapter, etc.).
6	5 and 4	676	
7	AND NOT ("case study" OR "case report" OR “systematic review”)		
8	6 and 7	**354**	This is the final sample