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1 **IN PRESS - BEHAVIORAL SLEEP MEDICINE**

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4 **Do people with chronic pain judge their sleep differently? A Qualitative study**

5

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Abstract

People with chronic pain often report sleep of “poor quality”. However, it is unclear what defines sleep quality and whether their sleep quality judgment is influenced by factors other than sleep. We purposively interviewed 17 participants with and without chronic pain and thematically analyzed their interview transcripts. Four salient criteria for judging sleep quality were: (i) *Memories of night-time sleep disruptions*, (ii) *Feelings on waking and cognitive functioning during the day*, (iii) *Ability to engage in daytime physical and social activity*, and (iv) *Changes in physical symptoms (and pain intensity among participants with chronic pain)*. Sleep quality judgment is complex and involves retrospective decision-making influenced by not only memories of the night but also how we feel and what we do during the day.

Keywords: sleep quality, chronic pain, physical activity, qualitative, thematic analysis

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Introduction

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Sleep quality is an elusive construct. Despite being a common criterion used to evaluate sleep, there is no authoritative definition of what sleep quality is and how it is being interpreted by the sleeper (Krystal & Edinger, 2008).

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Researchers and clinicians have developed different methods to operationalize the construct. Some use multi-component questionnaires that solicit information about sleep patterns, presence of sleep disturbances and use of sleep medications to generate a global index of sleep quality (e.g. Pittsburgh Sleep Quality Index; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). Some ask for an overall rating of sleep quality anchored with generic descriptions of sleep quality such as “very poor quality” or “very good quality”, as seen in sleep diaries (Carney et al., 2012). Additional items measuring “restfulness during sleep” or “refreshness on waking” have also been used to tap into the construct (Akerstedt, Hume, Minors, & Waterhouse, 1994; Wilson, Watson, & Currie, 1998). Some consider the amount of polysomnography-measured slow wave sleep and the level of sleep efficiency as the best physiological correlates of people’s subjective rating of sleep quality (e.g. Kerklund & Akerstedt, 1997). These methodological variations reflect the lack of consensus on what sleep quality entails, and although they are accepted methods for indexing sleep quality, they offer limited insights into the parameters people use to define their subjective sleep experience. There is also a tacit assumption that criteria used to judge sleep quality do not vary between individuals or clinical groups.

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Two previous studies have specifically explored the subjective meaning of sleep quality in people with and without insomnia. Harvey, Stinson, Whitaker, Moskowitz and Virk, (2008) used a combination of three approaches (a “speak freely” procedure, a semi-structured interview, and a week’s worth of sleep diary) to identify sleep quality variables

87 that are judged to be most important by insomniacs and compared these with those
88 variables highlighted by normal sleepers. Quantitative analyses of the data revealed that
89 “tiredness on waking and throughout the day” was the most frequently used variable for
90 defining sleep quality by both insomniacs (n=25) and normal sleepers (n=28). Importantly,
91 the authors also found that people with insomnia had a greater number of requirements for
92 judging sleep to be good quality than normal sleepers. Kleinman et al. (2013) conducted
93 focus groups with 28 patients with insomnia at clinical research sites to explore the
94 language people use to describe their sleep experience and sleep quality. The groups were
95 invited to talk about their typical sleep pattern and any night-to-night variations in sleep
96 they had experienced over the past weeks. They were also asked to write down words that
97 describe to them a good night’s sleep, which were then read to the group to generate
98 discussion. Transcripts of the focus groups were qualitatively analyzed for themes. Common
99 adjectives used to describe a good night’s sleep were “restful”, “peaceful”, “deep”, and
100 “sound”, whereas a bad night’s sleep was often characterised by both physical and cognitive
101 “restlessness”. Consistent with the findings of Harvey et al. (2008), the patients appeared to
102 define the quality of sleep primarily by their feelings on waking. Waking up feeling “tired”
103 and “exhausted” were indicators of poor sleep quality. On the contrary, waking up “in a
104 good mood”, feeling “refreshed”, “having clear mind”, and “motivated” to get things done
105 were indicators of good sleep quality. Transcripts of the focus groups were also reviewed by
106 insomnia diagnosis to uncover potential differences between participants with primary
107 insomnia and those with insomnia comorbid with another psychiatric or medical disorder.
108 However, this review did not identify any clear differences between groups in term of the
109 criteria they use to gauge sleep quality. Taken together, findings from both of these studies
110 suggest non-specific feelings upon waking- rather than objective parameters of sleep are

111 crucial in shaping our judgment of sleep quality. Cognitive-behavioral models of insomnia
112 have explicitly recognised that subjective appraisals of sleep are integral to the pathogenesis
113 of insomnia disorder (Harvey, 2002; Lundh & Broman, 2000; Morin, 1993). Identifying the
114 criteria that people use to judge their sleep quality may provide new inroads for improving
115 patients' sleep experiences and help explain reports of poor sleep quality not accompanied
116 by polysomnography- or actigraphy-measured sleep abnormalities (Harvey & Tang, 2012).
117 This could be of importance in terms of advancing the understanding and treatment of
118 insomnia comorbid with long-term health conditions such as chronic pain.

119 Sleep disturbance is highly prevalent among people living with painful conditions
120 (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006). Poor sleep quality is reported by as
121 many as 99% of patients with fibromyalgia- a long term condition marked by widespread
122 pain in the muscles, tendons, and ligaments (Theadom, Cropley & Humprey, 2007), whereas
123 clinical levels of insomnia were found in between 53 and 79% among mixed groups of
124 chronic pain patients seeking treatment from specialist pain clinics (McCracken, Williams, &
125 Tang, 2011; Tang, Wright, & Salkovskis, 2007). Patients often cite pain as a primary reason
126 for sleep disruption and poor sleep quality (Breivik et al., 2006; Morin, Gibson, & Wade,
127 1998), although a number of studies have also highlighted the role of cognitive and somatic
128 arousal during the presleep period and the presence of depression and dysfunctional belief
129 about sleep in predicting self-reported sleep quality (Smith & Haythornthwaite, 2004; Tang,
130 Goodchild, Hester, & Salkovskis, 2012; Theadom & Cropley, 2008). It remains to be
131 determined what are the key criteria for judging sleep quality among chronic pain patients
132 and to what extent these criteria differ by pain diagnosis.

133 The present study extended the investigation of sleep quality and definitions to
134 people with chronic pain, with a view to uncovering the common parameters they use to

135 judge their sleep quality. As sleep quality is a subjective judgment, we took an inductive
136 qualitative approach to explore the mental representations of sleep quality in the patients'
137 mind (Pope & Mays, 1995; Thomas, 2003). In depth one-to-one interviews were carried out
138 to provide the data and context for the researchers to interpret and extract meanings.
139 Three groups of participants with widespread musculoskeletal pain, localised
140 musculoskeletal pain and no pain were included to allow for a comparison of sleep quality
141 definitions across diagnostic groups (Egan et al., 2013; Tang et al., 2009).

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143

Method

Participants

145 Six participants with fibromyalgia, five participants with back pain, and six healthy
146 individuals were purposively sampled to respectively represent the presence of chronic
147 widespread musculoskeletal pain, chronic localised musculoskeletal pain, and the absence
148 of chronic pain. Participants were recruited through advertisements circulated within local
149 pain patient support groups and flyers displayed across the university campus and the local
150 community.

151 The inclusion criteria applicable to all participants were (1) aged between 18 and 65
152 years and (2) English-speaking. An additional inclusion criterion for participants in the
153 fibromyalgia or back pain group was the presence of pain for at least six months, which is in
154 line with the definition of chronic pain (IASP Task Force on Taxonomy, 1994). All participants
155 in the fibromyalgia and back pain groups confirmed that they had received a formal
156 diagnosis of fibromyalgia or back pain from a physician. Exclusion criteria applicable to all
157 groups were: (1) physical disabilities or neurological disorders that prevent them from
158 completing the questionnaire and/or attending the interview (e.g. visual impairment,

159 dementia); (2) severe psychiatric illnesses (e.g. psychosis); (3) sleep disorders that might
160 explain sleep disturbance (e.g., sleep apnea, narcolepsy). Note that participants were not
161 selected based on their sleep complaints, as the researchers were interested in exploring
162 the judgment of sleep quality across the whole spectrum.

163 Although expert consensus suggests that data saturation for qualitative analysis is
164 generally reached with 12 participants (Guest, Bunce, & Johnson, 2006), the current study
165 interviewed 17 participants in total to provide data for qualitative analysis.

166

167 *Procedure*

168 Potential participants who responded to the recruitment drive were screened for
169 eligibility over the phone. Those who met the inclusion and exclusion criteria were invited to
170 complete a questionnaire and attend a semi-structured interview. Written informed
171 consent was obtained from each participant prior to the commencement of the interview.
172 The protocol of this qualitative study has been reviewed and approved by the relevant
173 Research Ethics Committee.

174 Questionnaires were included to characterize the participants, and these comprised
175 a blank body manikin to assess the spread of pain (Lacey, Lewis, Jordan, Jinks, & Sim, 2005),
176 the Brief Pain Inventory to examine pain severity and interference (BPI; Cleeland & Ryan,
177 1994), Insomnia Severity Index to assess sleep problems (ISI; Bastien, Vallieres, & Morin,
178 2001), Epworth Sleepiness Scale to measure daytime sleepiness (ESS; Johns, 1991),
179 Multidimensional Fatigue Inventory to assess fatigue (MFI; Smets, Garssen, Bonke, & Haes,
180 1995), Hospital Anxiety and Depression Scale to assess symptoms of anxiety and depression
181 (HADS; Zigmond & Snaith, 1983), Dysfunctional Beliefs and Attitudes about Sleep Scale
182 (DBAS; Morin, Vallieres, & Ivers, 2007) to measure beliefs and attitudes about sleep, and

183 finally, several standard questions about the participants' demographics such as age, sex,
184 Body Mass Index (BMI), and employment status.

185 The semi-structured interview generated data for the qualitative analysis. Each
186 interview was about 40 minutes long. During the interview, participants were invited to talk
187 in depth about their current sleep patterns and how they make judgment about their sleep
188 quality. To ensure coverage of these topics, five open-ended questions (see Table 1) were
189 presented one at a time with supplementary questions from the researcher when a
190 clarification or an elaboration was required. Participants were encouraged to talk freely and
191 allowed to digress as they shared their experiences. This provided the researchers with rich
192 contextual information to better understand the meaning of the speech. At the end of the
193 interview, the participants were fully debriefed (i.e. being reminded of the aims of the
194 research, given an opportunity to ask questions or express concerns about the study, and
195 being asked if they would be agreeable to checking the themes extracted for accuracy at a
196 later stage) and were reimbursed for their travel expenses.

197 All interviews were audio-recorded and transcribed verbatim by an independent
198 professional transcriber. The transcripts were then reviewed by the interviewer (FR) and
199 another member of the research team (EA) for accuracy.

200

201 *Analysis*

202 The data set for the current study comprised 17 transcripts. A thematic analysis was
203 carried out on all transcripts in accordance with the Braun and Clarke (2006) guidelines. This
204 particular inductive data analysis approach was chosen because it allows the researchers to
205 explore criteria for judging sleep quality with the flexibility to generate unexpected insights
206 from the data. The procedure for thematic analysis is transparent and structured. This

207 minimizes the researchers' bias in summarizing the themes emerged, although some may
208 see this as a disadvantage because it limits the researchers' interpretative power. The
209 qualitative data analysis software, Nvivo10, was used to organize transcripts and to manage
210 the extraction of codes and emerging themes.

211 There were six key steps in analyzing the data. First, the lead author (FR) familiarized
212 herself with the data by reading and rereading the transcripts. Initial ideas and impression
213 related to the research questions were noted and highlighted. This step allowed the
214 researcher to develop a thorough understanding of the data. Second, initial codes (i.e. brief
215 description of the concepts identified from the data) were constructed as transcripts were
216 being read again. All the coded data were then collated and semantically arranged. Third,
217 potential themes were extracted from the coded data. Fourth, potential themes were
218 carefully reviewed. At this stage, the researcher consulted and discussed with a senior
219 researcher with clinical and research experience in pain and sleep (NT) regarding the
220 precision of the themes and the relevance of the coded data. Differences in opinions were
221 resolved by discussion. Fifth, to ensure our interpretation did not deviate from original
222 meaning of the data, the extracted themes and codes were sent to a subsample of the
223 participants (n= 7) for validation. Feedbacks from the participants were incorporated into
224 the final stage of analysis, which led to the naming of each theme. The coded data were
225 arranged into a table in accordance with the themes they supported. When generating the
226 themes, the researchers not only paid attention to words used by the participants, but also
227 the context in which the participants articulated themselves. Finally, the researchers
228 compared and contrasted the themes across fibromyalgia, back pain and the healthy
229 groups. This final step allowed the researchers to examine whether people with chronic pain

230 judged their sleep quality differently from those without chronic pain, and whether people
231 with fibromyalgia evaluated their sleep quality differently from people with back pain.

232 The reporting of the current study closely adheres to the consolidated criteria for
233 reporting qualitative research (COREQ) to promote comprehensiveness and transparency
234 (Tong, Sainsbury, & Craig, 2007).

235

236

Results

237 *Participant characteristics*

238 Table 2 presents the demographics and clinical characteristics of the participants by
239 group. Nine (52%) of the 17 participants were male, eight (48%) were female. Age of the
240 participants ranged from 19 to 64 years old, with a mean age of 42.1 years (SD= 15.5) and a
241 mean BMI of 27.9 (SD= 5.89). Of the 17 participants, 7 (41%) were in full-time employment,
242 7 (35%) were on sick leave, medically retired, retired or not working, and the remaining 3
243 (18%) were studying full-time.

244 Although no statistical analysis was performed on the questionnaire scores given the
245 small sample size and the qualitative nature of the current study, the overall pattern of data
246 appeared to suggest a stepwise progression in the spread of pain across the diagnostic
247 group (healthy controls < back pain < fibromyalgia). The same pattern of stepwise
248 progression by diagnostic grouping was also found for pain severity, pain interference,
249 insomnia severity, dysfunctional beliefs and attitudes about sleep, fatigue, anxiety and
250 depression. The only exception was daytime sleepiness, whereby the scores were identical
251 between the back pain and the health control groups, although both groups reported a
252 lower level of daytime sleepiness than the fibromyalgia group. Only the fibromyalgia group
253 had a mean score above the clinical threshold for ISI (23.1), ESS (10.3), and HADS (anxiety=

254 12.5; depression= 12.3). These scores indicated severe clinical insomnia, significant daytime
255 sleepiness, and probable presence of anxiety and mood disorders in the fibromyalgia group.

256

257 *Thematic Analysis*

258 Four salient themes emerged as criteria used by the participants to judge their sleep quality
259 (See Figure 1). Each of these themes is presented below with direct quotes from the
260 participants.

261 Theme 1: *Memories of night-time sleep disruptions*

262 There was a clear consensus that the participants judged their sleep quality based on
263 their remembered ability to “switch off” and stay asleep. Awakenings in the middle of the
264 nights were cited as indicators of poor sleep quality; the more memories of wakefulness,
265 the stronger the feeling of having had a bad night’s sleep. A good night’s sleep was typically
266 characterized by the general absence of interruptions to sleep and/or memory of noise or
267 any non-sleep activities, as illustrated by the quotes that follow:

268 “It’s that sensation of really I have switched off, I am not aware of anything.
269 That you know, those three hours where maybe the following day my
270 husband said to me, ‘Oh did you hear the thunderstorm last night?’ ‘No,’
271 because it happened on those three hours and I didn’t hear anything. I didn’t
272 hear the thunderstorm, I didn’t notice the light, nothing, and that is for me a
273 proper sleep. When I’m aware of everything else I’m not, and I get up
274 noticing that I have not slept properly” (Fibromyalgia, Female, 49).

275

276 “A good night’s sleep is that it’s not interrupted it will have little to no
277 interruption. I mean if I do wake up it will only be the once and it will be for
278 five minutes, when I am just sort of like hear a noise and I just roll over” (Back
279 Pain, Female, 19).

280

281 “There are some nights when I am woken up several times for whatever
282 reason, you know and it can be a combination of factors I might need to go to
283 the loo, or one of the boys might wake up, or the dogs, or George
284 [pseudonym] who makes equally as much noise and I suppose if I felt that my
285 sleep was very disturbed because of that, or because of a combination of
286 those factors, I would feel I had a poor night’s sleep” (Healthy, Female, 45).

287

288 Theme 2: *Feelings on waking and cognitive functioning during the day*

289 Feeling refreshed on waking emerged as a key criterion of good quality sleep.

290 Although it was unclear what exactly was meant by “feeling refreshed”, the participants

291 noted that on days when they felt refreshed by sleep they would be motivated to get up and

292 be ready to start the day without any hesitation. In contrast, a poor night sleep was

293 generally associated with a struggle to get up in the morning, tiredness on waking, and the

294 desire to stay in bed and get some more sleep. The feeling of being refreshed by sleep

295 appeared to be linked to the ability to overcome the sleep inertia upon transitioning from

296 sleep to wakefulness.

297 “I know when I’ve had a good night’s sleep because I would wake in the
298 morning feeling refreshed” (Fibromyalgia, Male, 41).

299

300 “A bad night’s sleep I feel bad the next day and a good night’s sleep I feel
301 refreshed, ready to go, on the ball” (Back Pain, Male, 64)

302

303 “It’s [a good night’s sleep] waking up fresh, get up easy, get stuck straight
304 into whatever tasks I have to do, whatever I’m going to do, as opposed to
305 having to will myself to climb out of bed and get organized” (Healthy,
306 Male, 63).

307

308 The participants also retrospectively judged their sleep quality based on their

309 daytime task performance. They noted that a night of poor sleep was typically followed by a

310 day of forgetfulness and mind-wandering. They cited that they would have difficulty in

311 finding words, struggle to stay focused on tasks, and be slow in thinking and retrieving

312 information. Whereas on a day when they were able to function well and think clearly, they

313 would typically consider themselves having had a good night’s sleep. There appears to be an

314 assumed direct link between sleep and daytime cognitive performance.

315 “I will be thinking and, and trying to explain stuff to you, but my mind will
316 just go completely blank. That gets worse on certain days, obviously with
317 less sleep, but on other days I can sort of string together” (Fibromyalgia,
318 Male, 41)

319
320 “I feel more alert. I do quite a physical job, but it, it’s very mental as well,
321 there’s a lot of measurements and stuff I have to take, and the days will
322 fly and everything’s clear, and if I haven’t had a good night’s sleep the run
323 of the mill jobs are quite problematic I have to really concentrate on stuff
324 that normally I could just fly through” (Back Pain, Male, 45).

325

326 “If I’ve had a bad night’s sleep I might have word finding difficulties, so,
327 because I teach, and so I’m standing there and I’m trying to explain
328 something and I feel slow selecting the words that I need to be able to
329 explain” (Healthy, Female, 53).

330

331 Theme 3: *Ability to engage in daytime physical and social activity*

332 Another index commonly used by the participants to gauge their sleep quality was
333 their ability to fully engage in physical and social activities during the day. The participants
334 cited that, following a poor night’s sleep they tended to find themselves avoiding social
335 engagements. Lacking energy, they would cancel appointments to give themselves an
336 opportunity to catch up on sleep. Daytime fatigue and social withdrawal during the day
337 were perceived to be indicators of poor quality sleep.

338 “Having a bit more energy say after a good night sleep I’ve got a bit more
339 energy to be able to go a whole day and to do things, after a bad night’s
340 sleep fatigue will hit me at say half 3 in the afternoon eventually, plug’s
341 pulled and I fall asleep standing up more or less” (Fibromyalgia, Male, 34).

342

343 “I say when I’m tired or if I’ve felt like I’ve had very little quality sleep, I
344 can become quite withdrawn, I don’t want to be involved, I don’t engage,
345 I don’t want to make conversation, so that is very much the opposite of
346 who I am. I mean I’m quite an enthusiastic person, quite an open person,
347 and will engage with, I will happily talk to anybody. I’m working in a job
348 where we interact with people, like staff and customers, and to then have
349 that day where, and other people notice and they will say to me, ‘Are you
350 okay?’ and, because it is very noticeable difference” (Back Pain, Female,
351 28).

352

353 “After a good night’s sleep, I’m more likely to do exercise because my day
354 will be more organized. So with a good night’s sleep I’m likely to be more
355 active”(Healthy, Female, 53).
356

357 Theme 4: *Changes in physical symptoms and pain intensity*

358 The participants paid attention to their bodily sensations when they made judgment
359 of their sleep quality. Physical symptoms (e.g., headache, migraine and sore eyes) and
360 unexpected loss of appetite were used to infer poor sleep quality.

361 “After a bad night’s sleep I usually wake up maybe with a headache and
362 my eyes quite tired or sore” (Healthy, Female, 25).

363
364 “If I have a good night’s sleep I feel that I don’t really have like a migraine,
365 and when I haven’t had much sleep I have a feeling of a headache, of a
366 migraine and also I don’t have as much like tension in my neck and
367 shoulders because I do find when I don’t have much energy, I do have
368 quite a lot of tension in my neck and shoulders so that’s how I sort of
369 know” (Back Pain, Female, 19)

370
371 “Sometimes when I’ve had a bad night my appetite goes as well. I have to
372 eat something to take my medication but I will force myself to eat a bit of
373 toast or something you know just so I’ve got something in my tummy to
374 take the tablets” (Fibromyalgia, Female, 45).

375

376 Additionally, for participants with fibromyalgia or back pain, they factored in their
377 current pain when judging sleep quality. These participants perceived an increase in pain as
378 an indicator of poor night’s sleep and showed appreciation of the self-perpetuating cycle of
379 pain and poor sleep. They believed that a poor night’s sleep would aggravate pain and fuel
380 the risk of re-injury. When describing the pain, the participants used words such as “tight”
381 and “swelling”. The choice of words appears to suggest that both musculoskeletal and
382 inflammatory mechanisms are involved in the reciprocal link of sleep and pain.

383 “After a bad night’s sleep, my muscles and my joints can be really quite
384 painful and tight cause I haven’t rested them properly” (Fibromyalgia,
385 Female, 45).

386

387 “I feel constantly in pain, which obviously when I don’t get enough sleep
388 will aggravate that, and then because I’ve aggravated pain I don’t get
389 enough sleep. So I am on a vicious cycle, I can’t sleep properly because of
390 the pain, and I can’t, because I am not sleeping, I then get in more pain”
391 (Fibromyalgia, Male, 41).

392
393 “If I’ve had a bad night and it’s painful it’s obviously because of the
394 swelling, because it will be like swelling in the bottom of the spine, so I
395 have to be careful all day in case I aggravate it even more, so, and, and it
396 plays on my mind because it’s there all day, so I am generally aware of it
397 more and I have to be so much more careful in case I injure it” (Back Pain,
398 Male, 45).

399

400

Discussion

401 Across participants with and without chronic pain, four key parameters emerged to
402 be key criteria for judging sleep quality. Namely, these criteria were “*memories of night-*
403 *time sleep disruptions*”, “*feelings on waking and cognitive functioning during the day*”,
404 “*ability to engage in daytime physical and social activity*” and “*changes in physical*
405 *symptoms and pain intensity*”. Introception of pain intensity, however, only applied to
406 participants from the fibromyalgia and back pain groups. Whereas previous studies have
407 predominantly focused on night-time parameters as correlates of sleep quality (Akerstedt et
408 al., 1994; Keklund & Akerstedt, 1997), the current findings suggest that sleep quality is also
409 influenced by daytime parameters. This may seem counterintuitive, but not so much when
410 considering that daytime dysfunction is core to the experience of insomnia and it is usually
411 one of the main reasons why individuals seek treatment for their sleep problems (Kyle,
412 Espie, & Morgan, 2010).

413

414 *Theme 1: Memories of night-time sleep disruptions*

415 To participants in the current study, being able to sleep through the night is a
416 fundamental criterion for a good night’s sleep. Indeed, multiple studies have shown that

417 subjective sleep quality was correlated with sleep efficiency, wake after sleep onset (WASO)
418 and number of wake bouts in the night (Bastien et al., 2003; Diaz-Piedra et al., 2015; Feige
419 et al., 2008; Keklund & Akerstedt, 1997; O'Donoghue, Fox, Heneghan & Hurley, 2009;). It is,
420 however, interesting to note that under normal circumstances most people do not have
421 access to sleep measuring technologies. As such, sleep quality judgments rest heavily on the
422 absence of memories of awakenings and the non-specific recollection that the mind has
423 "switched off". These underline the importance of successful formation of mesograde
424 amnesia during sleep in shaping subjective judgment of sleep quality (Perlis et al., 1997,
425 2001).

426 Several factors may play a role in shaping the sleeper's memory of wakefulness.
427 First, the duration and timing of the awakening. It has been suggested that if an awakening
428 marks only a brief period of arousal as short as 16 seconds on the PSG recording (Perlis et
429 al., 1997), then there is a good chance that the awakening would be forgotten and that it
430 would not disrupt the natural mesograde amnesia of sleep. However, it should be
431 mentioned that experimental induction of brief arousals (<3 seconds of minimum duration
432 of alpha activity) in healthy volunteers during the sleep onset period has been associated
433 with subjective reports of poor sleep quality and longer sleep onset latency that is not
434 reflected in the PSG recording (Smith & Trinder, 2000). Second, certain stages of sleep such
435 as N1 and REM can be easily experienced as wake, particularly in people with insomnia
436 (Mercer, Bootzin, & Lack, 2002). Although the exact mechanism underpinning this
437 phenomenon is not clear, the presence of excessive cognitive (e.g. worries) and
438 physiological (e.g. pain) arousal may play a role in interpreting sleep as wakefulness, by
439 blurring the distinction between wake and sleep during sleep onset period (Bonnet & Arand,
440 1992; Mercer et al., 2002). Third, memory of sleep can be influenced by the current mental

441 state of the sleepers. Hartmann and colleagues (2015) examined the correlation between a
442 retrospective measure of sleep quality based on the PSQI (i.e. for the last month) and a
443 prospective measure of sleep quality derived from two weeks of sleep diary in insomnia
444 patients with and without a comorbid psychiatric diagnosis. They found that the correlation
445 between the two sleep quality measures was moderated by mental health status, with a
446 significantly weaker association being found in insomnia patients with a comorbid
447 psychiatric diagnosis. These patients also had a higher PSQI score than those without a
448 psychiatric diagnosis, but this difference disappeared when the effect of anxiety was
449 partialled out. The authors therefore suggested that retrospective sleep quality judgment is,
450 to some extent, negatively biased by the mood states of psychiatric patients. Finally,
451 attentional bias towards sleep-related threat is a cognitive characteristic of people with
452 insomnia (Taylor, Espie & White, 2003; Semler & Harvey, 2007; Spiegelhalder et al., 2010).
453 Selective attention to and/or active monitoring of signs and cues of sleeplessness may also
454 contribute to participants' memory of wakefulness by increasing the load of information
455 processing and further elevating the levels of cognitive and emotional arousal.
456 Understanding these factors that influence memory of wakefulness may help explain the
457 often-observed discrepancy between the objectively estimated sleep and the sleeper's
458 subjective sleep experience (Harvey & Tang, 2012).

459

460 *Theme 2: Feelings on waking and cognitive functioning during the day*

461 Both participants with and without chronic pain evaluated their sleep quality using
462 information and cues that occur after sleep, on the subsequent day. In other words, people
463 inferred their sleep quality based on how they felt on waking and what they could and could
464 not do during the day. It is important to note that the retrospective nature of the sleep

465 quality judgment applies to not only the context of completing a questionnaire asking about
466 overall sleep quality, but also on a daily basis when people are asked to give a sleep quality
467 rating in the morning after each night of sleep. Non-specific feelings on waking appeared to
468 be an important indicator of sleep quality. Participants used generic terms such as
469 “unrefreshed”, “tiredness”, and “fatigue” to describe the effect of a poor night’s sleep,
470 highlighting an implicit assumption that one should be able to function well during the day
471 when their sleep is restorative.

472

473 *Theme 3: Ability to engage in daytime physical and social activity*

474 Following from the previous theme, sleep quality judgment is also defined by the
475 participant’s daytime physical and social activity. The assumed link between sleep and next
476 day activity apparently is bi-directional. In fact, participants even went as far as describing a
477 tendency to do more after having had a good night’s sleep and do less after having had a
478 bad night’s sleep. This is consistent with experimental findings reported by Semler and
479 Harvey (2005), who gave pre-determined sleep quality feedback to 22 adults with primary
480 insomnia who believed their sleep was being monitored and spontaneously analyzed. The
481 feedback was either positive (good quality sleep condition) or negative (poor quality sleep
482 condition) and was randomly given to the participants according to their assigned
483 experimental condition, remotely via a pager immediately on waking. Over the 3 days of
484 experiment, the authors found that the participants engaged in less physical activity (e.g.
485 cancelling appointments, taking a daytime nap) on days following the receipt of negative
486 feedback relative to positive feedback days. A similar association between perceived sleep
487 quality and subsequent physical activity has also been observed among chronic pain
488 patients in a daily process study conducted by Tang and Sanborn (2014), who asked 119

489 chronic pain patients with insomnia to monitor their sleep and physical activity in their
490 natural living and sleeping environment for a week. In addition to wearing an actiwatch
491 throughout the whole study, participants completed a daily electronic diary three times a
492 day to provide subjective ratings of their sleep quality, pain and mood upon waking, in the
493 first half of the day, and in the second half of the day. Fitting multilevel models on these
494 time-specific data, the authors discovered that sleep quality rating of the night before was a
495 significant determinant of the next day's physical activity as measured with actigraphy. Pain
496 and mood ratings in the morning, however, did not predict subsequent levels of physical
497 activity. These findings highlight a potential role of sleep quality judgment in the regulation
498 of physical activity in general and within the context of chronic pain. Physical inactivity is a
499 common issue of chronic pain (Hasenbring & Verbunt, 2010; Huijnen, Verbunt, Peters, &
500 Seelen, 2010; Mcloughlin, Colbert, Steghner, & Cook, 2011). It has been postulated in the
501 fear-avoidance model (FAM) as a form of avoidance behavior fuelled by pain catastrophizing
502 and the consequent fear of pain and re-injury (Asmundson, Norton & Vlaeyen, 2004;
503 Vlaeyen & Linton, 2000). For chronic pain patients with comorbid insomnia, subjective
504 perception of poor sleep quality may well be an additional factor that promotes more
505 focused attention on pain, negative thinking, and activity avoidance (Affleck, 1996;
506 Asmundson, Norton & Vlaeyen, 2004; Vlaeyen & Linton, 2000). There may be value applying
507 cognitive-behavioral therapy for insomnia (CBT-I) as an adjunct treatment for improving
508 sleep and daytime functioning in people with chronic pain (Jungquist et al., 2010; Tang,
509 Goodchild, Salkovskis, 2012), especially therapy with a cognitive component that addresses
510 subjective perception/evaluation of sleep quality (Harvey et al., 2007).

511

512

513 *Theme 4: Changes in physical symptoms and pain intensity*

514 Physical changes and bodily discomfort (e.g. lose of appetite, muscle tension) were
515 reported as signs of poor sleep quality across all participants with and without pain. These
516 findings are consistent with those of Harvey et al. (2008), who found that body sensations
517 on waking and throughout the day was mentioned by participants as a parameter of sleep
518 quality judgment. Different from pain-free individuals, participants with chronic pain tended
519 to focus their attention on subtle changes in pain spread and pain intensity and they used
520 their pain experience to infer how well they have slept the night before (e.g. "The pain has
521 been worse than usual this morning. I must have had a poor night's sleep"). Chronic pain
522 participants explicitly described their sleep and pain experience as a vicious cycle, with poor
523 sleep magnifying pain and worse pain resulting in further trouble sleeping. This type of pain-
524 related sleep belief, if held rigidly and inflexibly, may play a role in furthering sleep
525 disturbance and pain interference (Afolalu, Moore, Ramlee, Goodchild, & Tang, in prep).

526

527 *Strengths, limitations, and implications*

528 The current study is the first to uncover common parameters of sleep quality across
529 individuals with and without a pain condition. The findings from this study have provided
530 new insights into judgment of sleep quality from the sleepers' perspective and generated a
531 number of testable hypotheses about the reciprocal link between perceived sleep quality
532 and daytime functioning. However, generalizability of the results needs confirmation from
533 future empirical studies with larger samples. The qualitative nature of the study also means
534 that the researchers play an active role in analyzing and extracting themes from the data.
535 Interpretations of the data/themes may have been influenced by the researchers' personal
536 beliefs and biases, although we should note that several measures were taken to minimize

537 the researchers' biases, such as consulting a senior researcher and sending the codes and
538 extracted themes to a subsample of participants for validation. We closely followed the
539 Braun and Clarke (2006) guideline at each step of the analysis and provided example of
540 multiple quotes for each theme to ensure our interpretation of themes was fair and
541 transparent.

542 Findings emerged from the present study have a couple interesting implications.
543 Theoretically, if judgment of sleep quality is affected by not only memories of last night's
544 sleep but also feelings on waking and functioning during the day, sleep quality ratings may
545 vary throughout the day depending on the timing of assessment. Daily process studies with
546 multiple assessments of sleep quality will help clarify to what extent sleep quality changes
547 throughout the day and identify the contextual factors associated with these changes.
548 Future assessments of day-to-day sleep quality should consider factoring in the effect of
549 time. Standardizing the timing of sleep diary completion, for example, may help maximize
550 comparisons of sleep quality judgment between days, even within the same individual
551 (Carney et al., 2012). Clinically, it may be worthwhile educating the patients about the
552 influence of their sleep quality judgment on their subsequent daytime activities, as well as
553 the reverse inference of sleep quality based on mood, physical sensations, cognitive clarity,
554 and activities performed during the day. For patients with chronic pain, their use of pain as
555 an indicator of poor sleep appears to be stemming from the belief that sleep and pain
556 interact in a vicious cycle, with poor sleep magnifying pain and worse pain resulting in
557 further trouble sleeping. Loosening up this belief and eliminating pain from the sleep quality
558 judgment will allow the patient to embrace the treating of insomnia despite ongoing pain
559 (Tang, Goodchild, Hester, & Salkovskis, 2012; Afolalu, Moore, Ramlee, Goodchild, & Tang, in
560 prep). For patients with subjective insomnia not accompanied by objective sleep deficits,

561 promoting engagement in physical and social activities during the day may represent a new
562 avenue for improving sleep quality.

563

564 *Conclusion*

565 In conclusion, this present study extends our knowledge of the way people with and
566 without chronic pain judge their sleep quality. Sleep quality is not solely determined by
567 night-time parameters but also by daytime processes through retrospective judgment.
568 Particularly, people with chronic pain view pain experience and sleep quality as two linked
569 entities that influence their ability to engage in daytime activities as planned. To the sleeper,
570 using indirect indicators to infer sleep quality is only natural as they do not have access to
571 sleep assessment technology and the experience of sleep is marked by darkness, loss of
572 consciousness and amnesia. The current findings highlight the potential benefits of targeting
573 daytime symptoms in attempts to improve sleep quality. A possible extension of FAM
574 specifying the role of perceived sleep quality in influencing people's decision to engage in
575 daytime physical and social activity may also offer a more comprehensive framework for
576 understanding of chronic pain.

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Table 1
Interview Outline

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1. How would you describe your sleep? Can you tell me about your typical sleep pattern?
 2. How can you tell that you have had a good night's sleep?
 3. How can you tell that you have had a poor night's sleep?
 4. To you, what are the major difference between a good night's sleep and a poor night's sleep?
 5. Is there anything that you would like to add about your sleep?
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772 **Table 2**

773 Participant characteristics by group

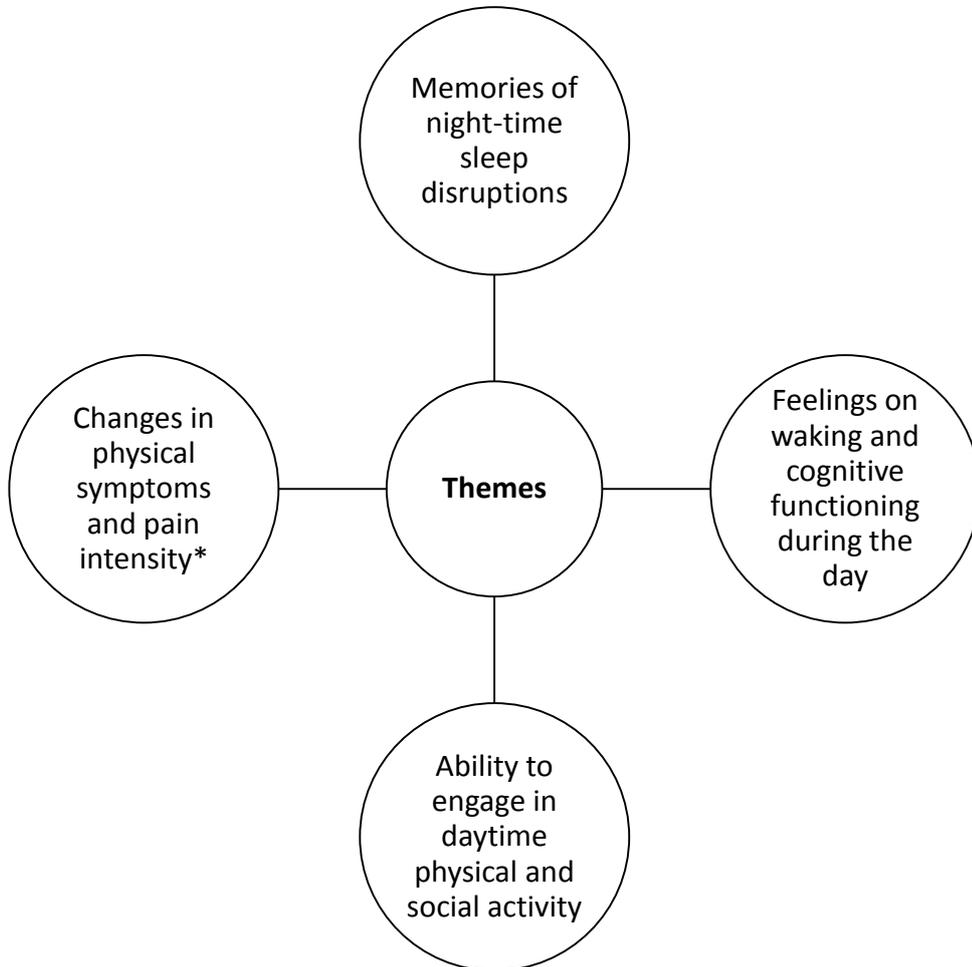
	Fibromyalgia (n= 6)	Back Pain (n= 5)	Healthy pain- free (n= 6)
<u>Demographics</u>			
Sex			
Male	3	3	3
Female	3	2	3
Age (in years)	49 (11.6)	35.2 (19.2)	41 (15.3)
BMI	27.8 (5.4)	32.4 (6.2)	24.2 (3.6)
Employment status			
Full-time employment	1	3	3
On sick leave/ medically retired/ retired/ not working	5	-	2
Full-time studying	-	2	1
<u>Clinical characteristics</u>			
Body manikins (number of area shaded)	24.5 (9.9)	4.2 (3.1)	N/A
BPI- Present Pain Severity	6.1 (0.5)	3.8 (0.9)	0.5 (1.0)
BPI- Pain Interference	8.3 (0.9)	3.8 (1.6)	0.5 (0.8)
ISI	23.1 (3.7)	14.4 (4.2)	8.3 (3.3)
ESS	10.3 (7.4)	6 (4.8)	6 (3.5)
DBAS-16	7.23 (1.4)	4.3 (1.8)	3.2 (1.3)
MFI	88.8 (11.8)	56 (10.4)	47.5 (18.9)
HADS(A)	12.5 (2.7)	7.6 (1.8)	5 (2.7)
HADS(D)	12.3 (2.3)	5.6 (2.8)	4 (2.5)

Notes. Mean values are presented with standard deviations in parentheses unless otherwise specified. BMI= Body mass index. BPI= Brief Pain Inventory. ISI= Insomnia Severity Index. ESS= Epworth Sleepiness Scale. DBAS-16= Dysfunctional Beliefs and Attitudes about Sleep. MFI= Multidimensional Fatigue Inventory. HADS(A)= Hospital Anxiety and Depression Scale (Anxiety). HADS(D)= Hospital Anxiety and Depression Scale (Depression).

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Figure 1
Themes emerged as criteria for judging sleep quality



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*Introception of pain intensity only applied to the fibromyalgia and back pain groups 796