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1 **Internet-delivered mindfulness for people with depression and chronic pain following spinal**
2 **cord injury; a randomised, controlled feasibility trial**

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5 Dr Jasmine Heath Hearn¹, Dr Katherine Anne Finlay²

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7

8 ¹The University of Buckingham Medical School, Hunter Street, Buckingham, MK18 1EG

9 ²The Department of Psychology, The University of Buckingham, Hunter Street, Buckingham, MK18

10 1EG

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18 *Requests for reprints should be addressed to Dr Jasmine Hearn, The University of Buckingham

19 Medical School, Hunter Street, Buckingham, MK18 1EG, United Kingdom (e-mail:

20 jasmine.hearn@buckingham.ac.uk).

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23 **Internet-delivered mindfulness for people with depression and chronic pain following spinal**

24 **cord injury; a randomised, controlled feasibility trial**

25 Key words: SCI; depression; web-based; ehealth; meditation; neuropathic pain

26

Abstract

27 **Study Design:** Between-subjects, randomised controlled feasibility study.

28 **Objectives:** Populations with reduced sensory and motor function are at increased risk of depression,
29 anxiety, and pain, and may be less geographically mobile. This study explored the efficacy and
30 feasibility of web-based mindfulness training for people with spinal cord injury (SCI).

31 **Setting:** UK community sample.

32 **Methods:** Participants were randomly allocated to an eight-week online mindfulness intervention (*N*
33 = 36), or to internet-delivered psychoeducation (*N* = 31). Depression symptom severity was the
34 primary outcome. Secondary outcomes included anxiety, quality of life (QoL), pain perception, pain
35 catastrophising, and mindfulness. Measures were taken before (T1), at completion of, (T2), and three
36 months following the intervention (T3).

37 **Results:** At T2, ten participants discontinued mindfulness training, and five discontinued
38 psychoeducation. Dropouts were of significantly older age. Nine participants were lost to follow-up.
39 Mindfulness reduced depression significantly more than psychoeducation at T2 (mean difference = -
40 1.50, 95% CI [-2.43, -.58]) and T3 (mean difference = -2.34, 95% CI [-3.62, -1.10]). Anxiety, pain
41 unpleasantness, and catastrophising were significantly reduced compared with psychoeducation. Total
42 mindfulness scores, and all facets of mindfulness except observing were significantly higher
43 following mindfulness training. At follow-up, reductions in anxiety and catastrophising persisted.

44 **Conclusions:** Internet-delivered mindfulness training offers unique benefits and is viable for people
45 with reduced sensory awareness. Future work should explore the feasibility of combined education
46 and mindfulness training. The use of brief interventions shows promise in maximizing participant
47 retention.

48

Introduction

49 Depression is commonly experienced following spinal cord injury (SCI), with a recent meta-analysis
50 indicating a mean prevalence rate of 22.2%¹, and is associated with chronic pain, with each one often
51 amplifying the other². However, conflict is evident in the literature in terms of interventions to
52 improve such outcomes, with some research trials, based on cognitive behavioural principles,
53 demonstrating improvements in depression², yet others reporting no change³. Indeed, systematic
54 reviews indicate a need for further evidence of the efficacy of psychological interventions for people
55 with SCI⁴. Similarly, qualitative work indicates that people with SCI desire improved access to
56 psychological interventions⁵, but have found the access to and SCI-appropriateness of such
57 interventions difficult to establish.

58 More recently, focus is being placed upon acceptance and mindfulness-based interventions
59 (MBIs), with the aim to develop present-moment awareness and acceptance, rather than changing
60 thoughts and behaviours⁶. Present-moment awareness is cultivated through attending to internal
61 experiences such as bodily sensations, thoughts and emotions in each moment, in a non-judgmental
62 manner⁶. Approach-focused strategies such as mindfulness are likely to be of value to those with SCI
63 and depression. Though benefits have been documented for people with multiple sclerosis, indicating
64 improvements in quality of life (QoL), mental health, and fatigue⁷, the utility of MBIs have not been
65 assessed in terms of their appropriateness for those with SCI.

66 Physical and psychological improvements, such as in anxiety and disability, arising from MBI
67 participation have been documented in various conditions, including chronic back pain⁸. MBIs
68 demonstrate small-to-medium effect sizes on psychological outcomes⁹. Work has shown
69 improvements in depression¹⁰, with preliminary results indicating that mindfulness is associated with
70 reduced experiential avoidance and improved mood in people with SCI¹¹. Proposed mechanisms
71 underlying the efficacy of MBIs include cognitive defusion (reduced identification with the contents
72 of one's thoughts), as well as improved self-regulation, emotional, cognitive and behavioural
73 flexibility, and exposure¹². Heightened awareness of automatic responses to emotions, thoughts, and
74 physical states is thought to offer more choice in countering habitual avoidance or denial of difficult
75 emotional or physical states and therefore increase exposure to such states (such as pain). For people

76 with chronic pain, this exposure, combined with the absence of catastrophic consequences, leads to
77 desensitisation to pain and reduced negative emotional reactivity⁹. Given that avoidance of negative
78 states is predictive of depression following SCI¹¹, and that mindfulness training can help to reduce
79 such avoidance, evaluation of the utility of MBIs for improving such important and potentially
80 debilitating outcomes after SCI is required.

81 Psychoeducation is often included as part of the rehabilitation process following SCI, with
82 NICE guidance recommending timely information on expected outcomes of treatment, return to usual
83 activities, and likelihood of permanent effects on quality of life, such as pain and psychological
84 outcomes¹³. Psychoeducation has previously been compared to mindfulness training for people with a
85 variety of chronic pain conditions, with subjective wellbeing improving more following mindfulness
86 training, and no differences between groups in improvements for pain interference, pain acceptance,
87 and catastrophising¹⁴. Despite its promise, no previous work has examined the efficacy of mindfulness
88 training for people with SCI, nor compared mindfulness with psychoeducation as an active control.
89 There therefore exists a need for research to evidence the utility of MBIs in comparison to
90 interventions such as psychoeducation that are offered as part of standard care during and after
91 rehabilitation following SCI.

92 This study, therefore, aimed to:

- 93 • explore the feasibility of eight-week online mindfulness and psychoeducation
94 interventions, specifically retention rates due to the high time commitment required
95 of participants.
- 96 • examine the utility of regular engagement with an online mindfulness training
97 intervention as a potential tool for people with SCI to enhance psychological
98 wellbeing.

99 Hypotheses:

- 100 • Mindfulness training will produce greater beneficial changes in psychological
101 wellbeing, and quality of life of people with SCI, compared with
102 psychoeducation.

103 • As the aim of mindfulness is not to reduce pain, it was anticipated that there
104 would be no differences in pain-related outcomes between mindfulness training
105 and psychoeducation.

106

107

108

Methods

Design

110 This was a between-subjects, single-center RCT, with depression symptom severity as the primary
111 outcome measure, and secondary outcome measures of quality of life, pain catastrophising,
112 mindfulness, and pain-related outcomes. A 2 x 3 design was employed, addressing the impact of the
113 intervention (2 levels; mindfulness training or psychoeducational control group), on each outcome
114 measure over time (3 levels; baseline, T1; post-intervention, T2; and three-month follow-up, T3).

115

Participants

117 Eligible participants were recruited from The National Spinal Injuries Centre, Stoke Mandeville
118 Hospital, UK, and had reduced sensory and motor function arising from SCI for a period of at least
119 one year. Participants were over 18 years of age (no upper age limit), had either paraplegia or
120 tetraplegia (see table 1), had chronic pain for a minimum of three months (screened using the LANSS
121 Pain Scale; with a minimum cut-score of 12¹⁵), sufficient understanding of English, and internet
122 access for the duration of the study. Exclusion criteria included: presence of any significant cognitive
123 impairment, mental illness or head injury (to reduce the risk of bias or influence on pain perception);
124 presence of any comorbid long-term health conditions that may affect the experience of SCI, or the
125 cause of chronic pain (such as cancer); and previous formal and informal experience of mindfulness
126 practice.

127

Procedure

129 Individuals meeting the inclusion criteria were identified by members of the direct care team at The
130 National Spinal Injuries Centre, and an advertisement was published in various local media outlets,

131 aimed towards people with SCI. Generic letters of invitation (i.e. neutral to the two groups) were sent
132 to all individuals who expressed interest in the study. If they wished to enroll in the study, participants
133 were screened for eligibility and recruited onto the study by members of the direct care team, at which
134 point informed consent was obtained and baseline data collected (T1). Following consent and baseline
135 measure completion, participants were then randomised using an independent, computerized random
136 block randomization programme, to receive either mindfulness training or the psychoeducational
137 intervention. Participants were blinded to their grouping and were not aware of the alternative
138 intervention approach until the study concluded. Participants were provided with the participant
139 information sheet specific to their grouping and given the opportunity to ask questions before the
140 intervention commenced. Participants then undertook their allocated intervention (described in further
141 detail below) for a period of eight weeks, after which outcome measures were taken (assessors were
142 not blinded to group allocation). Participants in the mindfulness training group did not receive any
143 psychoeducation and vice versa; interventions were delivered in addition to standard care. After the
144 final questionnaires were completed at three-month follow-up, all participants were debriefed. Upon
145 completion of the study, those in the control group were offered the opportunity to take part in the
146 mindfulness course, and those in the mindfulness group were provided with the psychoeducational
147 materials.

148

149 **Interventions**

150 Psychological interventions often necessitate multiple sessions/visits, which may pose a barrier to
151 engagement for people with SCI, given the reduced motor function resulting from injury. However,
152 both MBIs and psychoeducation can be delivered in an online format. In collaboration with the
153 Mindfulness Center in Sweden, Breathworks offers an established web-based, eight-week
154 Mindfulness for Health course¹⁶, specifically designed for people with chronic pain and/or illness
155 (also known as Mindfulness Based Pain Management). The decision to use a web-based course was
156 influenced by the fundamental need to use patient-centered approaches in physical medicine and
157 rehabilitation¹⁷, accounting for factors like geography, transport, and motor function. Patients with
158 sustained neurologic conditions, such as SCI, represent populations potentially at the greatest risk of

159 disadvantage due to concomitant physical, functional, and support-related limitations which may
160 reduce engagement with healthcare services¹⁸. Thus, to maximize engagement and reduce participant
161 burden, the online course was adopted for this study. Similarly, evidence supports its efficacy for
162 depression¹⁹ and chronic pain intensity and interference²⁰, making it an appropriate course for the
163 target population.

164 Participants were instructed to complete the course individually, at times and locations
165 appropriate to their lifestyles. The course delivered two, ten-minute audio-guided meditations each
166 day (recorded by trained and accredited mindfulness teachers), on six out of seven days a week, for
167 eight weeks, totalling 960 minutes of practice. Participants were led through a progressive
168 experiential exploration of mindfulness, including: breath awareness, body scanning, kindness, and
169 activities for embedding mindfulness in daily life¹⁹ (see table 1 for more detail on these aspects of the
170 course). One specific aspect of the course that was adapted by the course providers and authors was in
171 mindful movement, designed to promote awareness of physical activity. Mindful movement videos
172 were created to guide participants through a range of small movements that were considered more
173 feasible for people with reduced physical function, including head tilts and wrist rotations.
174 Participants were advised to do mindful movements that were appropriate to their level of function,
175 thus allowing bodily movement within the limits of physical capability. Engagement with the course
176 was monitored by the web host (Mindfulness Center in Sweden), and the authors were notified when
177 participants had completed the course. Participants were provided with a certificate of completion and
178 continue to have unlimited access to the resources online.

179

180 ***INSERT TABLE 1 HERE***

181

182 Participants in the psychoeducation group received an email once per week for eight weeks,
183 which provided educational content on SCI and chronic pain in lay terminology and were advised to
184 read these at times and locations suitable for them. This was based on the established elements found
185 in pain management psychoeducation programmes and detailed the epidemiology of SCI and SCI-
186 specific pain, including the biopsychosocial model, the relationship between mood and pain, and the

187 role of stress and unhelpful thoughts. Further topics included options for pain and psychological
188 management (pharmacological and non-pharmacological), and sources of further specific support.

189

190 **Measures**

191 Measures were administered via an encrypted online survey before (T1) and after the programme
192 (eight weeks; T2) and at three-month follow-up (T3) for both groups. Measures were selected in
193 accordance with recommendations by the Initiative on Methods, Measurement, and Pain Assessment
194 in Clinical Trials (IMMPACT) Group²¹; focus was placed on pain, emotional function, physical
195 function, mindfulness, and assessment of compliance with the interventions. All measures selected
196 demonstrate sensitivity to change.

197 **Demographics.** The demographic questionnaire contained nine items pertaining to age,
198 gender, employment and marital status, ethnicity, ASIA impairment score, cause, level of (cervical,
199 thoracic, lumbar, or sacral), and time since, injury.

200 **The Hospital Anxiety and Depression Scale (HADS)**²². This is a 14-item likert scale
201 measure; seven items assess severity of depression and seven items assess severity of anxiety, and
202 responses range from zero to three. Higher scores (range zero to 21 on each outcome) indicate greater
203 symptom severity. It is a reliable measure of severity of depression and anxiety in people without
204 physical restrictions, and those with SCI, without influence of injury-related bias (Cronbach's alpha
205 0.85 for HADS-A, 0.79 for HADS-D)²³. In the present study HADS-A $\alpha = .85$, HADS-D $\alpha = .92$.

206 **Quality of Life (WHOQoL-BREF)**²⁴: This 26-item questionnaire measures QoL in four
207 domains, graded on a 5-point likert scale: physical health, psychological health, social relationships,
208 and environment. Summed scores range from 0-100; higher scores denote greater perceived QoL.
209 Cronbach's alpha for the WHOQoL-BREF for all time points in the present study was between 0.86
210 and 0.96, consistent with previous work with people with SCI²⁵.

211 **Five Facet Mindfulness Questionnaire (FFMQ)**²⁶: The FFMQ consists of 39 items scored
212 on five-point Likert scales ranging from 1 (never/rarely true) to 5 (very often/always true). It
213 measures five factors representing mindfulness: observing, describing, acting with awareness, non-

214 judging of inner experience, and non-reactivity to inner experience, thus identifying which skills are
215 important predictors of symptom reduction. Facet scores range from 8 to 40, apart from the facet of
216 non-reactivity, which has a range from 7 to 35. The total maximum score on the FFMQ is therefore
217 195, with higher scores indicating greater levels of mindfulness. The FFMQ has strong psychometric
218 characteristics, including good reliability with alpha coefficients ranging from 0.72-0.92 for all facets
219 and significant incremental validity in previous work²⁶, and from 0.89-0.92 in the present study.

220 **Pain-related measures.** Numerical rating scale (NRS) measures on scales of zero (none) to
221 ten (as bad as it could be), of pain intensity, and pain unpleasantness, were included. The NRS'
222 demonstrated good reliability in the present study (pain intensity $\alpha = .78$, pain unpleasantness $\alpha =$
223 $.92$).

224 **The Pain Catastrophising Scale²⁷** is a 13-item likert-type scale which measures three
225 domains of catastrophising, including rumination, magnification, and helplessness. Higher scores
226 indicate increased pain-related catastrophising, with a minimum score of zero and maximum score of
227 52. Validity and reliability have been demonstrated with a Cronbach's alpha score 0.95 in previous
228 work²⁸ and in the present study.

229 **Retention Rates.** Retention rate was defined as discontinuation and loss to follow-up at three
230 months. As the study assessed the utility of regular engagement in mindfulness practice, compliance
231 was defined as completing all 960 minutes of the mindfulness course. The maximum attrition rate at
232 follow-up target of 20% was based on the mean attrition rate from systematic review evidence of
233 mindfulness interventions for people with multiple sclerosis (range 5-43%)²⁹.

234

235 **Statistical Methods**

236 Data were analysed using SPSS version 22. A sample size calculation was performed for the primary
237 outcome measure, depression symptom severity, using G*Power; for a power of 80%, a conservative
238 effect size of .25 (based on previous meta-analyses of psychological interventions for people with
239 SCI³⁰), two-tailed, with significance set at $p < .05$, a sample of 42 was necessary, protecting against
240 Type I error. To account for drop-out, a target of 66 participants was set for the sample.

241 Data were initially examined for distribution normality and outliers. Means and standard
242 deviations were calculated for demographic data. Multiple univariate analyses of covariance
243 (ACNOVAs) were applied to outcome measures in preference to multivariate analyses, controlling for
244 baseline scores for each outcome measure. Correlations were calculated between all outcome
245 measures at T2 and T3. Confidence intervals and effect sizes are reported throughout.

246

247 **Statement of Ethics**

248 This study was approved by The University of Buckingham School of Science and Postgraduate
249 Medicine Ethics Committee, the NHS Health Research Authority (ref: 14/SC/1424), the local
250 Research and Development office, and The National Spinal Injuries Centre. The trial was registered
251 prospectively with an International Standard Randomised Controlled Trial Number
252 (ISRCTN14165286).

253 All participants provided informed consent and were debriefed following completion of the
254 study. Ongoing support was offered by the researchers, and staff from the centre providing the online
255 course. All patient identifiable information and their corresponding data files were stored separately
256 on a password-protected computer at The Psychology Department at the University of Buckingham.
257 All applicable institutional and governmental regulations concerning the ethical use of human
258 volunteers were followed during the course of this research.

259

260

Results

261 A CONSORT flow diagram provides randomization information (see Figure 1). Participants were
262 recruited between April 2015 and March 2016, with recruitment ending when the target of 66
263 participants was met (the trial exceeded its required sample size through the use of multiple
264 recruitment strategies). Of the 94 assessed for eligibility, 67 were randomised across the two
265 interventions. Intention-to-treat principles were followed; Little's test indicated that cases were
266 missing at random ($\chi^2(3, N = 52) = 3.03, p = 1.00$), and therefore for participants who provided data
267 at T1 and T2, missing data points were imputed using multiple imputation. As a result, 67 participants

268 are included in analyses at T1, and 52 at T2 and T3. Both groups were normally distributed for all
269 outcome variables (Shapiro-Wilk; $p > .05$).

270

271 ***INSERT FIGURE 1 HERE***

272

273 **Demographic Characteristics**

274 Overall, there were 67 participants with 36 in the intervention group and 31 in the control group. Of
275 the sample, 31 (46%) were male, and mean age was 44.4 years. The majority of the sample were
276 white (86%), with 7% Bangladeshi and 7% Asian. The location of SCI was lumbar (7%), thoracic
277 (55%), or cervical (37%), with road traffic accident the most common cause of injury (40%), followed
278 by falls (24%), non-traumatic causes (18%), and sporting injuries (10%). Participants were most
279 commonly between two and eight years since the onset of their injury (55%), with 16% sustaining
280 their injuries within the past two years, and 38% sustaining their injuries over eight years ago.
281 Participant characteristics can be found in Table 2.

282

283 **Compliance Rate**

284 The total period taken to screen and enrol the sample size of 67 was 13 months. At T2, a total of 10
285 participants had discontinued the mindfulness training (28%), indicating a total intervention
286 compliance rate of 72%. Those who dropped out of mindfulness training completed an average of 217
287 minutes of practice (range 40 – 460 minutes). Five participants discontinued psychoeducation (16%),
288 indicating a total intervention compliance rate of 84%. Independent samples t-tests indicated that
289 those who discontinued were of significantly increased age ($M = 49.3$, $SD = 11.1$) compared to course
290 completers ($M = 43.0$, $SD = 9.9$, $p = .04$, $d = .599$, 95% CI [5.22, 7.38]). Further, severity of
291 depression symptoms approached significance, with participants discontinuing the intervention
292 demonstrating increased symptom severity ($M = 15.9$, $SD = 2.4$) compared to those who completed it
293 ($M = 13.8$, $SD = 4.0$, $p = .051$, $d = .637$, 95% CI [1.761, 2.439]). There were no other significant
294 differences between those who discontinued and those who completed the interventions on
295 demographics and outcome measures at baseline. Five further participants allocated to mindfulness

296 training (14%), and four allocated to psychoeducation (13%), were lost to follow-up at T3, with a
 297 total retention rate of 58% in mindfulness training and 71% in psychoeducation. There were no
 298 differences between study completers and those lost to follow-up on baseline measures or
 299 demographic variables at T3.

300

301 ***INSERT TABLES 2 AND 3 HERE***

302

303 **Effect of the Intervention**

304 Analysis of covariance (ANCOVA) was conducted for all outcome measures with baseline scores set
 305 as covariates in each analysis. Additionally, level of injury and ASIA scores were also controlled for,
 306 given that there were more people in the mindfulness training group with levels of injury at T1-T5
 307 and ASIA B scores compared with the psychoeducation group. At T2, significant improvements in
 308 favour of mindfulness training ($p < 0.05$) were found for severity of depression (partial eta squared
 309 $(\eta^2_p) = .184$; mean between group difference = -1.50, 95% CI [-2.43, -.58]), anxiety ($\eta^2_p = .137$; mean
 310 between group difference = -1.50, 95% CI [-2.60, -.40]), pain unpleasantness ($\eta^2_p = .137$; mean
 311 between group difference = -.96, 95% CI [-1.67, -.25]), and pain catastrophising ($\eta^2_p = .110$; mean
 312 between group difference = -2.26, 95% CI [-4.14, -.38]).

313 Significant differences at T2 were also noted for mindfulness facets of acting with awareness
 314 ($\eta^2_p = .220$; mean between group difference = 1.60, 95% CI [.716, 2.49]), describing ($\eta^2_p = .098$;
 315 mean between group difference = 1.43, 95% CI [.16, 2.69]), non-judging ($\eta^2_p = .081$; mean between
 316 group difference = 1.20, 95% CI [.01, 2.38]), and non-reactivity to inner experience ($\eta^2_p = .167$; mean
 317 between group difference = 1.36, 95% CI [.47, 2.25]), and the total FFMQ score ($\eta^2_p = .277$; mean
 318 between group difference = 6.25, 95% CI [3.28, 9.21]). There were no significant group differences at
 319 T2 for any aspect of QoL, pain intensity, and mindfulness facets of observing and non-judging.

320 At T3, significant group differences ($p < 0.05$) persisted for severity of depression ($\eta^2_p = .223$; mean
 321 between group difference = -2.34, 95% CI [-3.62, -1.10]), anxiety ($\eta^2_p = .112$; mean between group
 322 difference = -1.31, 95% CI [-2.39, -.23]), and pain catastrophising ($\eta^2_p = .239$; mean between group

323 difference = -3.77, 95% CI [-5.75, -1.80]). Means and standard deviations for each outcome measure
324 at each time point are reported in Table 3. Results of the ANCOVAs are reported in Tables 4 and 5.
325 Spearman's rho Correlation matrixes for all outcome variables are provided for T2 and T3 as
326 supplementary files (Tables 6 and 7).

327

328 ***INSERT TABLES 4 AND 5 HERE***

329

330

331

Discussion

332 This is the first study exploring the effects of an eight-week, internet-delivered mindfulness training
333 intervention for people with reduced sensory and motor function arising from SCI. Compared to
334 psychoeducation, online mindfulness training offered greater improvements in symptoms of
335 depression and anxiety, pain catastrophising, and specific facets of mindfulness (describing, acting
336 with awareness, non-reactivity to inner experience, and total scores) at completion of the intervention.
337 At follow-up, depression and anxiety severity and pain catastrophising demonstrated a persistent
338 decrease and were significantly lower in the mindfulness training group compared to the control
339 group. Pain unpleasantness, severity of anxiety, the WHOQoL subscales of physical and
340 psychological QoL, and the FFMQ facet of non-reactivity to inner experience significantly predicted
341 depression severity at intervention completion, whilst at follow-up, anxiety and pain unpleasantness
342 significantly predicted depressive symptom severity. At follow-up the largest effect size was
343 demonstrated for improvements in symptoms of depression, indicating a strong relationship between
344 engagement in mindfulness training, and improvement in this outcome.

345 The intervention completion rate was high (average 78%), indicating that the interventions
346 were viable and could be successfully embedded into daily life following SCI. However, the drop-out
347 rate was higher in mindfulness training (28%) compared with psychoeducation (16%). This may be
348 reflective of the difference in commitment required by the interventions, with mindfulness training
349 requiring twice daily participation in mindfulness practices, and psychoeducation requiring
350 participants to read educational materials once per week. Further, mindfulness training required active
351 participation and intrinsic motivation to log on for twice daily mindfulness practice, whilst
352 participation in the psychoeducation group involved more passive participation. The increased time
353 commitment and active engagement required in mindfulness training may have acted as a barrier to
354 engagement³¹, whilst provision of materials via email in the psychoeducation group may have reduced
355 participant burden.

356 People who discontinued the intervention were likely to display more severe symptoms of
357 depression, and were of increased age, suggesting that adherence to the intervention was more
358 difficult for these subgroups. Depression severity acts as a predictor for drop-out in internet-delivered

359 interventions³². Increased time and effort required of those with more severe psychological
360 difficulties, who may have past experience of unsuccessful treatment, may result in difficulties in
361 continuing an intervention³¹. Similarly, increased age may act as a barrier to engagement through
362 potential loss of social support for continuation in an intervention, as well as differential use of the
363 internet³². The present study suggests a need to establish more effective methods of supporting people
364 with comorbid conditions, such as depression and SCI, and those who are of older age with physical
365 disabilities, in order to facilitate improved engagement in psychological interventions and improved
366 outcomes.

367 In the present study, improvements seen in symptoms of depression and anxiety are
368 supportive of work by Skinner, Robertson, Allison, Dunlop, and Bucks¹¹, who found a negative
369 correlation between mindfulness and depression for people with SCI, a relationship mediated by
370 avoidance. This suggests that cognitive reappraisal initiated through mindfulness training may have
371 increased acceptance and influenced the way in which participants responded to emotions and
372 thoughts associated with depression and anxiety, such as reduced experiential and behavioural
373 avoidance. These results echo the beneficial effects noted in previous trials with people with multiple
374 sclerosis⁹ and chronic back pain⁸. They also support previous evaluation of the course¹⁹, which
375 demonstrated immediate improvements following completion in measures of depression, positive
376 outlook, catastrophising, activities engagement, and pain acceptance, with medium-to-large effect
377 sizes supporting each result. Online mindfulness training, may therefore initiate changes in the way
378 that participants appraised emotions, thoughts, and events, with beneficial effects for emotional
379 aspects of life after SCI, which is echoed by the results of the present study, particularly in relation to
380 depression and catastrophic thinking.

381 Pain catastrophising was significantly reduced by mindfulness training, over and above the
382 observed change in the control group, an improvement seen immediately upon completion of the
383 course, and at three-month follow-up. It is likely that cognitive reappraisal or ‘uncoupling’ the
384 sensory experience of pain from the emotional and cognitive experience of pain occurred, which
385 decreased negative emotional responses to its presence. Recent work supports this, indicating that the
386 way that people with SCI think and talk about chronic pain may reflect catastrophic thinking, and

387 increase the attention paid to pain³³. The training programme adopted in the present study has been
388 specifically developed for people with chronic physical health conditions, which may mitigate this
389 contradiction in results. Such improvements could therefore be further enhanced with MBIs that are
390 specifically targeted for populations with reduced sensory awareness and motor function. The
391 reduction in catastrophising in the present study suggests that mindfulness training initiated cognitive
392 reappraisal, interrupting the amount of focus placed upon pain. This is supported by the change in
393 perception of pain unpleasantness evidenced in the present study, highlighting potentially increased
394 psychological flexibility and ability to hold an awareness of pain without negative judgement, or
395 getting embroiled in pain-related cognitions and attempts to control pain.

396 Pain unpleasantness was reduced to a greater extent in the mindfulness training group
397 compared to psychoeducation at completion of the course, but not at follow-up. Mindfulness training
398 may instigate cognitive reappraisal of personal experiences and a change in perspective of the self;
399 this may occur through a process of learning about the relationship between mood and pain and thus a
400 change in the perceived meaning of pain³⁴. Further, decreases in perceived barriers to emotional and
401 pain management, and increased acceptance of pain and personal experience may also play a role in
402 reducing pain perception. However, future work should aim to describe the mechanisms underlying
403 changes in perceived pain unpleasantness and explore the extent to which reduced perception of pain
404 unpleasantness requires continued engagement with mindfulness practice.

405 In summary, the results of the present study show promise, with internet-delivered
406 mindfulness improving some outcomes to a higher degree than standard psychoeducation and
407 demonstrating its utility as an intervention for improving awareness for people with reduced sensory
408 and motor function. This study, therefore, provides a foundation on which to explore the impact of
409 mindfulness-based interventions for other neurological groups, and provides rationale for the
410 development of MBIs and mindfulness meditations sensitive to the specific needs of people with
411 neurological deficits.

412

413 **Limitations and Future Research**

414 This study explored the feasibility and impact of an eight-week mindfulness training intervention on
415 depressive symptom severity, anxiety, quality of life, and pain-related outcomes in people with SCI.
416 The overall study drop-out rate was high (36%) and the results are representative of people who have
417 engaged with all 960 minutes of mindfulness practice. A convenience sample was recruited through
418 advertisement of the study in media outlets could pose risk of selection bias, with those expressing
419 interest more likely to demonstrate improvements in targeted outcomes. Those who completed the
420 course and engaged fully with the educational materials may have been more motivated to engage in
421 self-care, and therefore may be more likely to experience positive change. It would be of benefit to
422 follow up those who discontinued mindfulness training, exploring the effects on wellbeing and their
423 motivations for dropping out. This would provide information to enhance adherence, reduce barriers
424 to training, and establish the relationship between mindfulness practice, and health-related outcomes.

425 The present study marks the first step in investigating the benefit of mindfulness for people
426 with SCI, highlighting immediate benefits. Future work is required to rigorously evaluate the
427 mechanisms of change underlying the effects of specific aspects of mindfulness and psychoeducation
428 on psychosocial outcomes after SCI. Similarly, work should explore the feasibility of combined
429 education and mindfulness training, for optimum benefit, and the use of brief interventions to
430 maximize participant retention.

431

432

433

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438

Conflict of Interest Statement

440 The authors declare no conflicts of interest.

441

442 **Supplementary Information**

443 Spearman's rho Correlation matrixes for all outcome variables is provided for T2 and T3 as
444 supplementary files.

445

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Figure 1. CONSORT Flow Diagram.

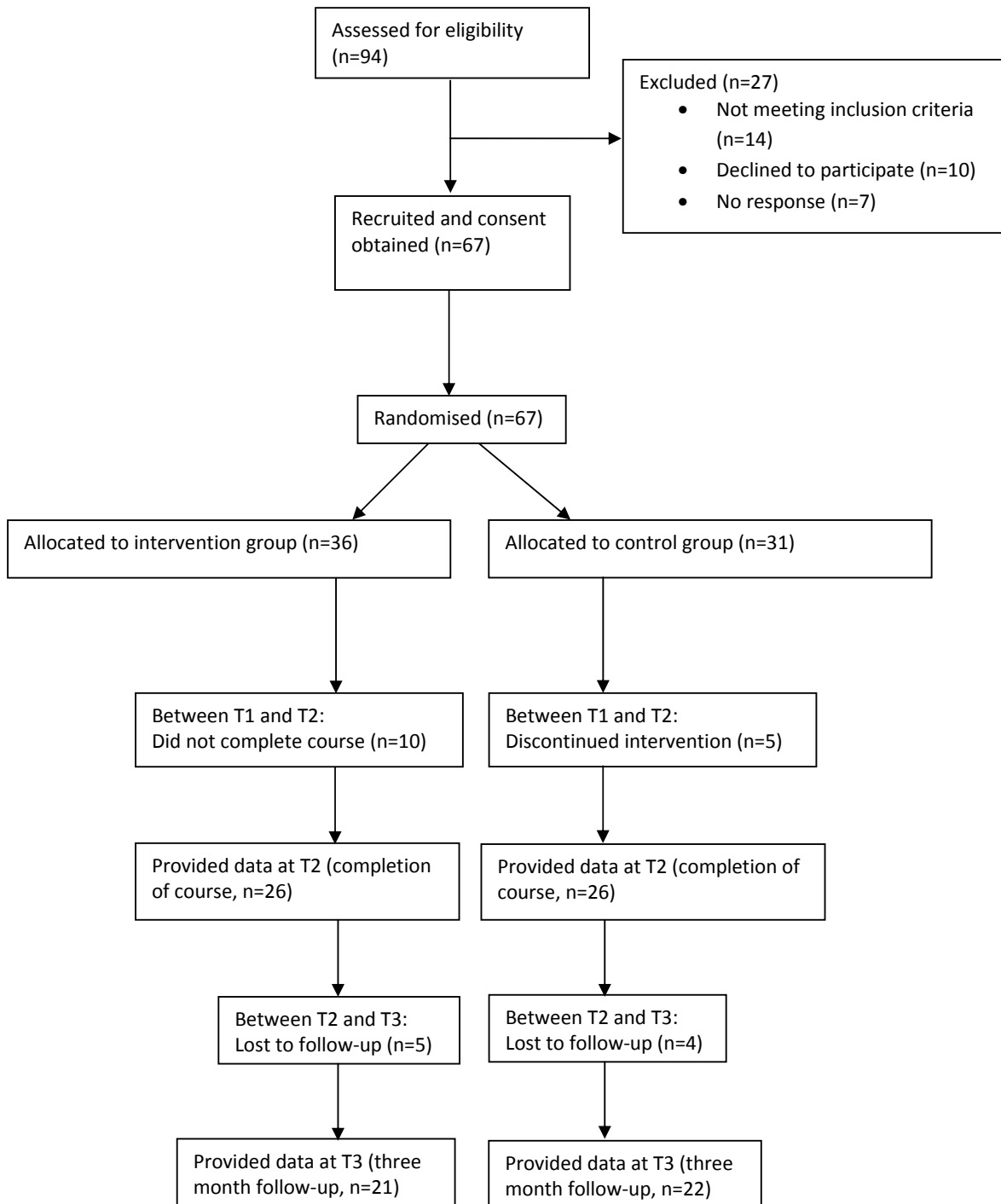


Table 1. Details on mindfulness course content.

<u>Week</u>	<u>Content</u>
1	The course began with an introductory video showing participants how to navigate the online server. The first week of the course started with three variants of the body scan, during which participants draw their attention to various areas of the body, moving awareness systematically through each area of the body, noticing actual sensations of the body in a precise and detailed manner, as opposed to attending to thoughts, ideas or fears about these sensations.
2	Participants were introduced to breath awareness meditations, alongside a fourth variant of the body scan. Breath awareness meditations began with a broad awareness of the bodily experience of breathing, becoming increasingly focused on more subtle aspects of breathing and encouraged participants to notice when their attention wandered away from the meditation.
3	Mindful movement was introduced, accompanied by body scans. The mindful movement meditation requires that the participant engage in bodily movements in time with their in- and out-breaths, allowing the pace to be dictated by the natural breath. Altered movements were designed specific to the abilities of those with SCI, and participants were able to choose which movements to engage in dependent on their ability. Videos of movements were provided. This week encouraged participants to bring awareness to their physical activity. This also aimed to teach individuals to pace themselves as they go about daily activities, as opposed to completing as many as possible whilst they feel well.
4	Meditations to foster acceptance and self-compassion were introduced, with participants encouraged to treat themselves with the kindness that they would treat others with and relax into pain, rather than being distressed by it.
5	Participants were encouraged to seek out the pleasant things in life, which pain and suffering may have prevented them from appreciating, by exploring each of their senses. This aimed to allow individuals to become more receptive to positives in their life, no matter how small. Participants were also encouraged to stop once an hour during daily life to find something positive. Meditations focused on developing the capacity to notice pleasant aspects of experience.
6	Encouraging the cultivation of broad, stable, kind, and confident awareness continued. Resistance of unpleasant experiences and grasping on to positive experiences was discouraged, whilst enjoyment of the depth and breadth of experience, both positive and negative, was encouraged. In this, participants were asked to acknowledge experiences, and to respond, rather than react, in order to improve their ability to

	choose adaptive responses.
7	This week introduced meditations that encouraged a kind attitude of connectedness and shared experience to oneself, friends, and others (for example, a person with whom the individual holds a difficult relationship with).
8	During the final week, participants were reminded of all they had learnt during the course. Self-compassion and kindness to others meditations were practiced for three days, followed by body scan and breath awareness meditations, which were practiced for the remaining three days. Participants were then presented with a downloadable certificate confirming their completion of 20 hours (960 minutes) of focused training.

Table 2. Demographic characteristics.

		Intervention Group (N=36)		Comparison Group (N=31)		Total (N=67)	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
	Age	43.8	8.7	45.2	12.2	44.4	10.4
		<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
Gender							
	Male	17	47	14	45	31	46
	Female	19	53	17	55	36	54
Marital status							
	Married	11	31	9	29	20	30
	Widowed	0	0	5	16	5	7
	Divorced	3	8	1	3	4	6
	Cohabiting	3	8	4	13	7	10
	Single	19	53	12	39	31	46
Employment status							
	Employed, full time	8	22	5	22	13	19
	Employed, part time	11	28	8	28	19	28
	Unemployed	7	22	8	22	15	22
	Retired	10	28	10	28	20	30
Ethnicity							
	White British	28	78	23	74	51	76
	White Irish	3	8	0	0	3	5
	European	1	3	1	3	2	3
	Other white	1	3	0	0	1	2
	Bangladeshi	3	8	2	7	5	7
	Asian	0	0	5	16	5	7
Cause of injury							
	Road traffic accident	16	44	11	36	27	40
	Fall	9	25	7	23	16	24
	Sporting injury	5	14	2	7	7	10
	Non-traumatic	6	17	6	19	12	18
	Prefer not to say	0	0	5	16	5	8
Level of injury							
	C1-C8	12	33	13	42	25	37
	T1-T5	13	36	5	16	18	27
	T6-T12	9	25	10	32	19	28
	L1-L5	2	6	3	10	5	7
ASIA Score							
	A	3	8	6	19	9	13
	B	13	36	4	13	17	25
	C	9	25	10	32	19	28
	D	11	31	11	36	22	32
	E	0	0	0	0	0	0
Years since injury							
	1-2	5	14	6	19	11	16
	2-4	11	31	7	23	18	27
	4-8	11	31	8	26	19	28

8-12	3	8	3	10	6	9
12-15	3	8	4	13	7	10
15+	3	8	3	10	6	19

n.b. percentages have been rounded.

Table 3. Self-report outcome measures: Means and standard deviations.

		Intervention			Control		
		T1 (N = 36)	T2 (N = 26)	T3* (N = 26)	T1 (N = 31)	T2 (N = 26)	T3* (N = 26)
WHOQoL-BREF							
Physical	Mean	52.3	54.6	55.0	52.9	55.8	56.8
	SD	5.0	5.0	6.2	6.4	5.2	5.2
Psychological	Mean	56.8	61.2	61.2	58.5	61.9	60.6
	SD	6.7	5.5	5.8	6.9	7.3	6.5
Social	Mean	58.6	65.4	69.1	57.2	63.0	65.2
	SD	8.1	7.9	10.8	8.6	7.3	9.4
Environmental	Mean	63.2	64.4	65.3	56.7	60.2	62.4
	SD	7.3	6.6	7.9	8.2	8.0	8.0
HADS							
Depression	Mean	15.6	12.6	11.3	12.7	11.8	11.3
	SD	2.9	3.2	3.6	4.1	3.2	3.5
Anxiety	Mean	14.5	11.6	11.2	13.1	12.0	11.6
	SD	3.9	3.2	3.2	4.1	3.7	3.7
Pain Intensity	Mean	6.5	5.0	4.7	7.3	5.6	5.5
	SD	2.1	1.4	1.6	2.0	2.2	2.3
Pain Unpleasantness	Mean	7.0	5.0	5.0	7.9	6.4	6.1
	SD	1.8	1.2	1.5	2.1	2.0	2.3
PCS	Mean	29.0	26.1	24.9	36.5	34.5	34.6
	SD	6.2	6.2	6.1	9.0	9.5	9.6
Mindfulness Total (FFMQ)	Mean	110.7	121.6	121.6	120.2	122.2	123.3
	SD	27.5	20.7	20.3	31.7	31.7	32.3
Observing	Mean	20.3	22.2	22.8	21.9	23.0	23.7
	SD	6.9	5.7	6.3	6.9	6.5	7.0
Describing	Mean	19.8	21.3	21.2	23.4	23.4	23.6
	SD	6.4	5.7	7.2	7.2	7.7	8.2
Acting with awareness	Mean	23.0	25.3	25.1	24.6	24.6	25.1
	SD	7.0	5.4	6.0	6.8	7.0	7.8
Non-judging	Mean	23.3	25.6	25.9	24.9	25.2	25.5
	SD	6.0	4.8	6.8	6.7	6.8	8.4
Non-reactivity	Mean	24.3	27.1	26.6	25.3	26.0	25.4
	SD	6.4	4.8	5.1	6.8	6.6	6.2

WHOQoL-BREF = World Health Organization Quality of Life Brief Scale. HADS = Hospital Anxiety and Depression Scale. PCS = Pain Catastrophising Scale. FFMQ = Five Facet Mindfulness Questionnaire.

*N.B. Pooled Means and Standard Deviations

Table 4. Analysis of covariance for group effects at T2. (N = 52)

Measure	<i>F</i>	<i>p</i> -value	η^2_p	Mean Difference T2 (mindfulness – control)	95% CI for T2 mean difference (lower, upper)
HADS					
Depression (0 – 21)	10.61	.002*	.184	-1.50	-2.43, -.58
Anxiety (0 – 21)	7.46	.009*	.137	-1.50	-2.60, -.40
WHOQoL-BREF					
Physical (0 – 100)	.61	.438	.013	-.63	-2.25, .99
Psychological (0 – 100)	2.08	.155	.043	1.25	-.49, 2.99
Social (0 – 100)	1.11	.298	.023	1.56	-1.42, 4.54
Environment (0 – 100)	.17	.898	.000	.11	-1.55, 1.77
Pain Intensity (0 – 10)	.60	.442	.013	-.39	-1.39, .62
Pain Unpleasantness (0 – 10)	7.44	.009*	.137	-.96	-1.67, -.25
PCS (0 – 52)	5.83	.020*	.110	-2.26	-4.14, -.38
FFMQ					
Total (39 – 195)	17.97	.000*	.277	6.25	3.28, 9.21
Observing (8 – 40)	3.83	.056	.075	.76	-.02, 1.55
Describing (8 – 40)	5.13	.028*	.098	1.43	.16, 2.69
Acting with Awareness (8 – 40)	13.23	.001*	.220	1.60	.716, 2.49
Non-judging (8 – 40)	4.15	.047*	.081	1.20	.01, 2.38
Non-reactivity (7 – 35)	9.41	.004*	.167	1.36	.47, 2.25

* = $p < 0.05$

WHOQoL-BREF = World Health Organization Quality of Life Brief Scale. HADS = Hospital Anxiety and Depression Scale. PCS = Pain Catastrophising Scale. FFMQ = Five Facet Mindfulness Questionnaire.

Table 5. Analysis of covariance for group effects at T3. (N = 52)

Measure	<i>F</i>	<i>p</i> -value	η^2_p	Mean Difference T3 (mindfulness – control)	95% CI for T3 mean difference (lower, upper)
HADS					
Depression (0 – 21)	13.55	.001*	.223	-2.34	-3.62, -1.10
Anxiety (0 – 21)	5.99	.023*	.112	-1.31	-2.39, -.23
WHOQoL-BREF					
Physical (0 – 100)	1.40	.330	.028	-1.33	-3.93, 1.27
Psychological (0 – 100)	3.48	.119	.068	2.08	-.18, 4.33
Social (0 – 100)	1.78	.224	.036	3.14	-1.72, 8.00
Environment (0 – 100)	.29	.674	.006	-.67	-2.36, 2.54
Pain Intensity (0 – 10)	1.01	.345	.021	-.48	-1.45, .57
Pain Unpleasantness (0 – 10)	1.52	.239	.031	-.54	-1.42, .34
PCS (0 – 52)	14.87	.001*	.239	-3.77	-5.75, -1.80
FFMQ					
Total (39 – 195)	3.00	.225	.058	4.49	-1.64, 10.61
Observing (8 – 40)	.82	.551	.017	.55	-1.17, 2.27
Describing (8 – 40)	1.15	.517	.023	.91	-1.54, 3.35
Acting with Awareness (8 – 40)	.68	.551	.014	.72	-1.66, 3.10
Non-judging (8 – 40)	.92	.595	.019	1.09	-2.34, 4.53
Non-reactivity (7 – 35)	3.85	.135	.073	1.48	-.26, 3.23

* = $p < 0.05$

WHOQoL-BREF = World Health Organization Quality of Life Brief Scale. HADS = Hospital Anxiety and Depression Scale. PCS = Pain Catastrophising Scale. FFMQ = Five Facet Mindfulness Questionnaire.