Understanding Discrepancies in a Person's Fear of Movement and Avoidance Behavior: A Guide for Musculoskeletal Rehabilitation Clinicians Who Support People With Chronic Musculoskeletal Pain
Peer-reviewed author version

Understanding discrepancies in a person's fear of movement and avoidance behaviour:

a guide for musculoskeletal rehabilitation clinicians who support people with chronic

musculoskeletal pain.

Liesbet De Baets[1], PhD, PT, Ann Meulders[2,3],PhD,PSY, Stefaan Van Damme[4],PhD, PSY, JP Caneiro[5,6],

PhD, PT, Thomas Matheve, PhD, PT[,7,8]

[1] Pain in Motion Research Group (PAIN), Department of Physiotherapy, Human Physiology and Anatomy, Faculty of Physical Education & Physiotherapy, Vrije Universiteit Brussel, Brussel, Belgium

[2] Experimental Health Psychology, Clinical Psychological Science, Maastricht University, Maastricht, The Netherlands

[3] Health Psychology, Faculty of Psychology and Educational Sciences, KU Leuven, Leuven, Belgium

[4] Ghent Health Psychology Research Group, Department of Experimental-Clinical and Health Psychology, Ghent University, Ghent, Belgium

[5] Curtin University, School of Allied Health, Faculty of Health Sciences, Perth, Australia

[6] Body Logic Physiotherapy, Perth, Australia

[7] Spine, Head and Pain Research Unit Ghent; Department of Rehabilitation Sciences, Ghent University, Ghent, Belgium.

[8] Faculty of Rehabilitation Sciences, Hasselt University, Hasselt, Belgium

Corresponding author:

Liesbet De Baets, Laarbeeklaan 103 - 1090 Brussels – Belgium

Liesbet.de.baets@vub.be

Word count: 3000

Understanding discrepancies in a person's fear of movement and avoidance behaviour:

a guide for musculoskeletal rehabilitation clinicians who support people with chronic

musculoskeletal pain.

Acknowledgements

The authors acknowledge the patient (Eva) for sharing her story.

1   **Abstract**

2   **Background**: Generic self-report measures do not reflect the complexity of a person's pain-related

3   behaviour. Since variations in a person's fear of movement and avoidance behaviour may arise from

4   contextual and motivational factors, a person-centred evaluation is required—addressing the

5   cognitions, emotions, motivation and actual behaviour of the person.

6   **Clinical Question**: Most musculoskeletal rehabilitation clinicians will recognise that different people

7   with chronic pain have very different patterns of fear and avoidance behaviour. However, an

8   important remaining question for clinicians is "how can I identify and reconcile discrepancies in fear

9   of movement and avoidance behaviour observed in the same person, and adapt my management

10   accordingly?".

11   **Key Results**: We frame a clinical case of a patient with persistent low back pain to illustrate the key

12   pieces of information that clinicians may consider in a person-centred evaluation (i.e., patient

13   interview, self-report measures and behavioural assessment) when working with patients to manage

14   fear of movement and avoidance behaviour.

15   **Clinical Application**: Understanding the discrepancies in a person's fear of movement and avoidance

16   behaviour is essential for musculoskeletal rehabilitation clinicians, as they work in partnership with

17   patients to guide tailored approaches to changing behaviours.

18

19   Key Words: behavioural assessment; safety behaviour; pain-related fear; pain avoidance; pain
20   management; chronic pain

21 **1.   Introduction**

22 Among the many drivers of pain and disability in chronic musculoskeletal pain conditions[26, 41, 42], fear

23 of movement and avoidance behaviour have consistently been linked with poor treatment response[19,

24 [21, 37, 44, 57]. Early theories suggested fear as the sole motivator for avoidance[51]; contemporary evidence

25 indicates that contextual and motivational factors play a major role in the relationship between pain,

26 fear and avoidance[32, 47, 50, 59, 61].

27

28 Different people make sense of their pain in different ways—based on their own experiences and

29 personal context—which may explain differences in fear of movement and avoidance behaviour

30 between different people (e.g., some patients may avoid painful activities, others may persist with

31 them)[7, 9, 10]. Insights into inter-individual differences are highly valuable, yet, they do not fully explain

32 discrepancies that are apparent *within* the same person—arising from contextual and motivational

33 factors. For example, a patient may disclose to you that she avoids certain painful activities, while

34 persisting with other activities even though the activities are painful. Another patient may avoid

35 specific behaviours during a behavioural assessment, despite a low score on the Tampa Scale for

36 Kinesiophobia (TSK))[14, 35, 46] that you might reasonably interpret as indicating low fear of movement.

37

38 Based on previous recommendations[65], clinicians might strongly rely on total scores of generic self-

39 report measures to guide treatments targeting fear of movement and avoidance behaviour, while

40 these measures alone might not be the most appropriate selection criteria. Therefore, a substantial

41 proportion of patients with low scores on general self-report measures but who display clear

42 avoidance behaviour that interferes with their daily functioning might not be offered appropriate

43 treatment.

44

45 It is essential that clinicians understand the process of a person-centred approach to evaluating fear

46 of movement and avoidance behaviour, and how to identify and manage within-person discrepancies

47   in the assessment. Therefore, we build on and extend previous work[8, 13, 65] by focusing on (1)

48   understanding within-person discrepancies in fear and avoidance behaviour; (2) how to interpret

49   individual items (rather than total scores) of self-report measures of fear of movement to better

50   understand a person's problem and guide adequate treatment selection; (3) how to complete an in-

51   depth behavioural assessment to identify safety behaviours and discuss safety behaviours from

52   different viewpoints; and (4) designing behavioural treatment that is informed by a person-centred

53   assessment of fear of movement and avoidance behaviour. We illustrate our approach with a clinical

54   case.

55

56   **2.   Clinical Question**

57   Most musculoskeletal rehabilitation clinicians will recognise that different people with chronic pain

58   have very different patterns of fear and avoidance behaviour. However, an important remaining

59   question for clinicians is "how can I identify and reconcile the variable pattern of fear of movement

60   and avoidance behaviour in my patient, and design a behavioural treatment based on a person-

61   centred assessment of fear of movement and avoidance behaviour for this patient?".

62

63   **3.   A person-centred approach to evaluating fear of movement and avoidance behaviour**

64   When assessing fear of movement and avoidance behaviour, a person-centred evaluation is required

65   that addresses the cognitions, emotions, motivation and actual behaviour of the individual person in

66   the relevant context[47]. A person-centred evaluation includes (1) an in-depth interview, to understand

67   the person's narrative and specific context regarding their fear of movement and avoidance

68   behaviour[7, 9, 11, 13], (2) an individual item-based analysis of the self-report measures to delve into

69   specific items and reveal additionally relevant information, and (3) a behavioural assessment that

70   evaluates the feared activities, to elicit beliefs and emotional responses to specific movements and

71   identify safety behaviours[31] (**FIGURE 1**).

72

73 The approach enables clinicians to identify within-person discrepancies that may exist, and manage

74 them appropriately. We present detailed information from the interview, common self-report

75 measures and the behavioural assessment from one of our patients, and highlight the value of each

76 of these components (see **TABLE 1** and **FIGURE 2**).

77

78 3.1. Interview

79 Eva reported that she initially avoided flexion to control her low back pain. Currently she avoids flexion

80 because she is afraid to cause more damage (**TABLE 2** - Quote 1). Eva's fear and protective behaviour

81 was influenced by an unhelpful explanation of her imaging results, and by her own beliefs about back

82 pain that were very much aligned with current societal beliefs (**TABLE 2** - Quote 2)[15]. Although Eva

83 believed that exercising and being physically active would help keep her back healthy, she was

84 convinced that only controlled exercises or activities performed with caution, where she could avoid

85 lumbar flexion, were appropriate for her (**TABLE 2** - Quote 3).

86

87 Quote 3 (**TABLE 2**) exemplifies how Eva's avoidance behaviour spanned from subtle safety behaviours

88 (e.g., putting her steer in a high position to avoid lumbar flexion during cycling) to complete avoidance

89 (e.g., not dancing with her daughter anymore) depending on the type of activity and context. Quote 4

90 (**TABLE 2**) highlights Eva's competing goals, as she indicated that the social relevance of continuing

91 cycling with her husband outweighed the goal of avoiding pain and potential harm. In contrast,

92 cleaning the house is a painful activity she did not enjoy, and thus avoided.

93

94 Another example of the importance of motivation and goal competition is the fact that Eva had not

95 been absent from work since her complaints, although she attributed the origin of her back pain to

96 her sedentary and stressful job. Because she valued her job and felt highly responsible for the

97 organization and her team, Eva persisted despite her pain while at work (**TABLE 2** - Quote 5).

98

99   3.2 <u>Item-based analysis of self-reported measures</u>

100   Various systematic reviews have shown only marginal to weak associations between general self-

101   report measures assessing fear of movement and the actual behaviour[14, 35, 46]. In Eva's case, there was

102   a discrepancy between the *total scores* on the generic self-report measures, indicating a low level of

103   fear of movement (see **TABLE 1**), and the information gathered during the interview and behavioural

104   assessment, indicating the presence of harm beliefs and avoidance behaviour (see **TABLE 1**, **FIGURE 2**

105   and 3.1. patient interview). Although the total scores from self-report measures assessing fear of

106   movement may be informative, we also recommend analyzing how individual items are scored, as this

107   may reveal additional information.

108

109   When analysis of individual item-responses may indicate the presence of fear of movement, or when

110   discrepancies are present (between item-responses on the self-report measure, or with information

111   from the interview or behavioural assessment), further in-depth discussion of individual items with

112   the patient is useful. However, an extensive item-based discussion may not have to be prioritised

113   when there are no indications of fear of movement and avoidance behaviour based on the patient

114   interview, behavioural assessment, and item-analysis of self-report measures. Therefore, therapists

115   should decide when, to what extent and which individual items to discuss. In **SUPPLEMENTARY**

116   **MATERIAL 1** we provide an overview of Eva's scores on the isolated items of the TSK, FABQ and

117   PHODA-SeV, and explain how discrepancies in Eva's answers to the individual TSK items led to new

118   insights on item-interpretation.

119

120   Here, we discuss the individual item-based analysis of the PHODA-SeV, and how it helped our

121   understanding on the context-dependency of Eva's perceived harmfulness. Eva's total score of

122   31.8/100 on the PHODA-SeV indicated a low level of perceived harmfulness. The item-based analysis

123   revealed that Eva generally scored flexion-related activities higher (mean score= 64.8/100) than non-

124   flexion-related activities (mean score= 23.8/100), indicating that she particularly perceived *flexion-*

125 *related movements* as harmful. However, even between the various flexion-related tasks, there was a

126 large variability in perceived harmfulness. By discussing the different items with Eva, it became clear

127 that her harm beliefs were dependent on specific activity characteristics (See **TABLE 3** for details).

128 Discussing the patient's answers to specific items of self-report measures is thus an important source

129 of additional information to the patient interview and it helps guide an individualised behavioural

130 assessment.

131

132 3.3 Behavioural assessment

133 We focused on flexion-related activities in Eva's behavioural assessment. Eva had an upright habitual

134 sitting position with over-activity of the lumbar extensor muscles (**FIGURE 2** A). When asked to slouch,

135 she was unable to relax these muscles and flex her lumbar spine (**FIGURE 2** B). When asked how this

136 slouched position felt, Eva reported she felt something was out of place in her lower back, and that

137 she experienced a grinding feeling.

138

139 Flexion in standing (**FIGURE 2** C) and lifting a 5 kg crate in her habitual way were predominantly

140 performed via hip flexion, with very limited lumbar movement and with strong co-activation of the

141 lumbar extensor and abdominal muscles. When she was asked what she thought would happen if she

142 had to flex her lumbar spine to lift the crate, Eva indicated that her back would not be strong enough

143 and it would buckle. Correspondingly, she said she would not be able to get back up again. When

144 asked how performing the task in her habitual way made her feel, Eva indicated that although she was

145 afraid, she felt somewhat reassured and safe with the physical therapist by her side. However, she

146 mentioned that she would be more fearful and likely avoid the lifting manoeuvre with a heavier crate,

147 especially if the physical therapist would not be present.

148

149 Thorough behavioural assessment is imperative, even for patients who do not self-report high levels

150 of fear of movement as it may highlight within-person discrepancies. An emotional response may only

151   be triggered when one is confronted with the feared activity, or when one believes the task needs to

152   be performed, while simply viewing pictures of feared activities may not suffice for these emotions to

153   surface[12, 31]. The standard inclusion of the behavioural assessment is thus of low cost but high benefit.

154

155   **4. Theory informing practice to help Eva manage her back pain**

156   In this section, the outcomes on the different components of the person-centred evaluation are

157   interpreted and discussed considering relevant theoretical models. Details on these theoretical

158   models are provided in **SUPPLEMENTARY MATERIAL 2**.

159   It has been suggested that total scores on questionnaires might offer a quick and robust method for

160   the initial screening of potentially suitable patients for further assessment and behavioural treatment

161   targeting fear and avoidance[65]. Clinical studies investigating exposure therapy in vivo for

162   musculoskeletal pain have used cut-off scores on the TSK as an inclusion criterion[3, 30, 38, 73]. We

163   recommend that clinicians avoid using total scores when selecting treatments, given the clear

164   discrepancy between the total scores on the self-report measures (TSK, FABQ, PHODA-SeV), and the

165   information gathered from the interview and behavioural assessment.

166

167   Preliminary evidence indicates that the scores on behavioural avoidance tests, in contrast to the total

168   TSK score, predict reduction in global disability after exposure treatment for chronic low back pain[34].

169   Interpreting total scores in isolation may therefore lead to misleading conclusions and inadequate

170   treatment choices. For example, one might inappropriately classify Eva as a person without fear of

171   movement (and avoidance behaviour), and deem further testing or treatment of fear of movement as

172   unnecessary. In **TABLE 4**, more information is provided on the limitations of self-report measures

173   assessing fear of movement and avoidance behaviour.

174

175 Eva initially avoided flexion-related and sudden, uncontrolled movements because they were painful.

176 Unhelpful messages from a health care professional and her social environment were central drivers

177 of her damage beliefs (**SUPPLEMENTARY MATERIAL 2** – fear acquisition).

178 A person might completely avoid activities or show subtle behavioural adaptations, the so-called

179 safety behaviours, which are specific adaptations that aim to prevent the feared outcome

180 (**SUPPLEMENTARY MATERIAL 2** – avoidance behaviour and safety behaviour)[47, 48]. Fear of movement

181 and avoidance behaviour can spread excessively to safe activities, which are conceptually or

182 perceptually similar to originally-feared or avoided movements or activities (**SUPPLEMENTARY**

183 **MATERIAL 2** – (over)generalisation)[29]. From a motivational perspective, safety behaviours may be

184 considered as an attempt to continue to participate in activities a person values from a social

185 perspective (e.g., Eva cycling with her husband) or a health perspective (e.g., Eva exercising to keep

186 her back healthy) (**SUPPLEMENTARY MATERIAL 2** – goal persistence)[16, 19, 59, 60].

187

188 Eva showed complete avoidance as well as safety behaviour. For example, although Eva loved to play

189 with her children (e.g., dancing and playing football), she completely avoided these activities as she

190 feared the sudden and uncontrolled movements would damage her back. This complete avoidance

191 clearly interfered with valued activities and participation (**SUPPLEMENTARY MATERIAL 2** - goal

192 interference), and negatively affected her mood[48]. A key example of Eva's safety behaviour is the

193 bracing of her spine to avoid flexion, which enables her to participate in her hobbies and continue

194 working, despite the pain she feels during these activities.

195

196 Eva wanted to continue cycling as she values the time she can spend with her husband and because

197 she can do this activity in a controlled manner by using her safety behaviour. She continues to work

198 as she feels responsible for the company (**SUPPLEMENTARY MATERIAL 2** – inter-goal relations).

199 However, she hired someone to clean the house, as cleaning was not an activity she enjoyed.

200

201 While safety behaviours may initially result in reduction of pain, fear and its related disability, it is

202 hypothesized that they may have negative consequences in the long term[13, 23] . In Eva's case, her

203 stereotypical spinal bracing with continuous overactivation of spinal muscles can become a source of

204 ongoing peripheral nociceptive input by loading spinal structures in an unhelpful manner, which in

205 turn can contribute to the persistence of pain[25, 33, 52] (See **TABLE 5** for more information). Although

206 causal inference cannot be made, this is indirectly supported by clinical evidence showing that

207 decreased safety behaviour during activities (e.g. greater spinal range of motion, faster movement,

208 more relaxed postures and less back muscle activity) is associated with less pain and experienced

209 disability during those particular activities[70-72].

210

211 Using stereotypical (i.e., invariable) motor strategies is related to higher levels of pain during repetitive

212 or prolonged movement tasks[1, 25, 55]. Performing activities with safety behaviours may also

213 paradoxically increase the fear of performing these activities via so called *ex-consequentia* reasoning:

214 "I'm avoiding, so it must be painful or harmful, and/or I must be afraid"[64, 66]. While safety behaviours

215 might have negative consequences in the long term, safety behaviours may also ensure engagement

216 in valued activities. Identifying safety behaviours during the behavioural assessment to decide to what

217 extent they need to be addressed is therefore of great importance.

218

219 **5.   Implications for behavioural management**

220 Eva had low total scores on self-reported measures. However, we recommended in vivo exposure

221 therapy as she was very frightened of performing key tasks in her life that she believed were harmful

222 for her back. Eva avoided valued activities, rendering her disabled[23]. We suggest that adequately

223 exposing Eva to her feared and valued activities is central to her recovery.

224 During exposure therapy, patients are exposed to the feared activities in order to challenge and

225 disconfirm their unhelpful beliefs. For example, Eva could be asked to lift an object by flexing her

226 lumbar spine. By experiencing that the feared outcome (i.e., buckling of the lower back) did not occur,

227 her expectations are challenged and new associations (i.e., lifting with a bent back is safe) learned.

228 Repeated exposures strengthen new associations so that they will be more easily retrieved and guide

229 behaviour when Eva is confronted with the feared situation. This is essential for extinction of the

230 avoidance behaviour and re-engagement in activities. Earlier theoretical models of exposure therapy

231 suggested that extinction of an avoidance behaviour depended on reducing fear during exposure.[36]

232 However, within and between session fear reduction is not a good indicator of learning and it does

233 not predict treatment outcomes.[4, 36] The inhibitory learning theory has been proposed as an

234 alternative explanation.[18] A central tenet of inhibitory learning theory is that maximising the

235 expectancy violation during exposure is essential to enhance extinction learning.[18, 68] In **TABLE 6**, we

236 demonstrate how this goal can be achieved.

237

238 Although exposure therapy is an effective treatment for patients with fear of movement and

239 avoidance behaviour,[30, 40] many of its principles described to improve exposure therapy have not yet

240 been investigated in clinical musculoskeletal pain populations. Consequently, there is an urgent need

241 for properly designed studies investigating these theoretical models, especially in (musculoskeletal)

242 pain populations.

243

244 There are strong theoretical arguments for disallowing safety behaviours during exposure.[14, 18]

245 However, there is inconclusive empirical evidence for either allowing or removing safety behaviours

246 during exposure[49]. Moreover, some argue for judicious use of safety behaviours, as they may be a

247 strategy for pursuing valued life goals[49, 56]. For example, Eva puts the steer of her stationary bike in

248 the highest position, so she does not have to bend her back too much, which allows her to participate

249 in a highly-valued social activity with her husband (**TABLE 2** – Quote 3). In this case, the potential

250 benefit (i.e., achieving a valued life goal) should be weighed against the potential cost (i.e.,

251 preservation of Eva's fear that bending will damage her back) of making a slight postural adjustment

252 during a very specific activity.

253

Excessive spinal co-activation is a more generalised safety behaviour that Eva uses during various

activities. Besides the negative impact on extinction learning, this behaviour comes with a high cost

as it may be an important reason for her persistent pain, and consequently, it is clear that it should be

discouraged during Eva's exposure treatment.

258

An important clinical goal is to guide patients to understand the principles underpinning treatment

(i.e., why safety behaviour is discouraged) so they can apply the new strategies at home and at work,

and during other valued activities. An important caveat here, is that the role of safety behaviours in

the context of (musculoskeletal) pain has mostly been investigated in a small number of experimental

studies[43, 63, 66, 67]. Although these studies show that allowing safety behaviours during exposure does

protect from extinction of pain-related fear, these findings need to be validated in clinical samples

with musculoskeletal pain. Indeed, since the experience of increased pain during behavioural

experiments by disallowing safety behaviours can cause severe emotional distress, integrated

behavioral approaches such as exposure with pain control have already been advocated for patients

with chronic musculoskeletal pain[53].

269

6. Key points

Findings: Total scores on generic self-report measures fail to capture all the relevant information

regarding fear of movement and avoidance behaviour, and thus inaccurately reflect the complexity of

pain-related behaviour. A person-centred evaluation addresses the cognitions, emotions, motivation

and actual behaviour of the individual person in the relevant context – identifying the variable pattern

of fear of movement and avoidance behaviour in one person. Specific attention during behavioural

assessment and treatment should be directed to a person's safety behaviours as these may become

potential sources of local peripheral nociception and reinforce harm beliefs, contributing to the

278   persistence of pain. Combining knowledge from various theoretical frameworks can explain

279   discrepancies in a person's fear of movement and avoidance behaviour.

280   Implications: Although clinicians might find it challenging to perform, interpret and implement a

281   person-centred evaluation of fear of movement and avoidance behaviour, it is necessary to gain all

282   relevant information to understand the problem and to guide appropriate treatment choices.

283   Caution: Part of the reasoning that justifies the clinical approach is based on assumptions and

284   treatment principles from theoretical models. While there is emerging evidence from (mostly)

285   experimental studies supporting these theoretical models, properly designed studies in clinical

286   populations are necessary to validate the assumptions.

287   <u>Study details</u>:

288   Author contributions: all authors contributed to the concept and design of this clinical commentary,

289   including preparation, writing, and final approval of the manuscript. L. De Baets takes responsibility

290   for the integrity of the commentary, from inception to the finished article.

291   Data sharing: There are no data in this manuscript.

292   Patient and public involvement: we present the case of a real patient who provided consent for sharing

293   the content that is outlined in this manuscript. We used an alias for anonymity purposes.

294

295   References

296   1.   Abboud J, Nougarou F, Pagé I, Cantin V, Massicotte D, Descarreaux M. Trunk motor
297   variability in patients with non-specific chronic low back pain. *Eur J Appl Physiol*.
298   2014;114:2645-2654.
299   2.   Ansanello W, Dos Reis FJJ, Tozzo MC, et al. Development of the Avoidance Daily Activities
300   Photo Scale for Patients With Shoulder Pain. *Phys Ther*. 2022;102:
301   3.   Ariza-Mateos MJ, Cabrera-Martos I, Ortiz-Rubio A, Torres-Sánchez I, Rodríguez-Torres J,
302   Valenza MC. Effects of a Patient-Centered Graded Exposure Intervention Added to Manual
303   Therapy for Women With Chronic Pelvic Pain: A Randomized Controlled Trial. *Arch Phys Med*
304   *Rehabil*. 2019;100:9-16.
305   4.   Baker A, Mystkowski J, Culver N, Yi R, Mortazavi A, Craske MG. Does habituation matter?
306   Emotional processing theory and exposure therapy for acrophobia. *Behaviour research and*
307   *therapy*. 2010;48:1139-1143.
308   5.   Beales D, Kendell M, Chang RP, et al. Association between the 10 item Örebro
309   Musculoskeletal Pain Screening Questionnaire and physiotherapists' perception of the
310   contribution of biopsychosocial factors in patients with musculoskeletal pain. *Man Ther*.
311   2016;23:48-55.
312   6.   Blakey SM, Abramowitz JS. The effects of safety behaviors during exposure therapy for
313   anxiety: Critical analysis from an inhibitory learning perspective. *Clin Psychol Rev*. 2016;49:1-
314   15.
315   7.   Bunzli S, Smith A, Schütze R, Lin I, O'Sullivan P. Making Sense of Low Back Pain and Pain-
316   Related Fear. *The Journal of orthopaedic and sports physical therapy*. 2017;47:628-636.
317   8.   Bunzli S, Smith A, Schütze R, Lin I, O'Sullivan P. Making Sense of Low Back Pain and Pain-
318   Related Fear. *Journal of Orthopaedic & Sports Physical Therapy*. 2017;47:628-636.
319   9.   Bunzli S, Smith A, Schütze R, O'Sullivan P. Beliefs underlying pain-related fear and how they
320   evolve: a qualitative investigation in people with chronic back pain and high pain-related
321   fear. *BMJ Open*. 2015;5:e008847.
322   10.   Bunzli S, Smith A, Watkins R, Schütze R, O'Sullivan P. What Do People Who Score Highly on
323   the Tampa Scale of Kinesiophobia Really Believe?: A Mixed Methods Investigation in People
324   With Chronic Nonspecific Low Back Pain. *Clin J Pain*. 2015;31:621-632.
325   11.   Caneiro JP, Bunzli S, O'Sullivan P. Beliefs about the body and pain: the critical role in
326   musculoskeletal pain management. *Braz J Phys Ther*. 2021;25:17-29.
327   12.   Caneiro JP, O'Sullivan P, Smith A, Moseley GL, Lipp OV. Implicit evaluations and physiological
328   threat responses in people with persistent low back pain and fear of bending. *Scand J Pain*.
329   2017;17:355-366.
330   13.   Caneiro JP, Smith A, Bunzli S, Linton S, Moseley GL, O'Sullivan P. From Fear to Safety: A
331   Roadmap to Recovery From Musculoskeletal Pain. *Phys Ther*. 2022;102:
332   14.   Christe G, Crombez G, Edd S, Opsommer E, Jolles BM, Favre J. Relationship between
333   psychological factors and spinal motor behaviour in low back pain: a systematic review and
334   meta-analysis. *Pain*. 2021;162:672-686.
335   15.   Christe G, Pizzolato V, Meyer M, Nzamba J, Pichonnaz C. Unhelpful beliefs and attitudes
336   about low back pain in the general population: A cross-sectional survey. *Musculoskeletal*
337   *Science and Practice*. 2021;52:102342.
338   16.   Claes N, Vlaeyen JWS, Crombez G. Pain in context: Cues predicting a reward decrease fear of
339   movement related pain and avoidance behavior. *Behav Res Ther*. 2016;84:35-44.
340   17.   Cook C, Wright A, Wittstein J, Barbero M, Tousignant-Laflamme Y. Five Recommendations to
341   Address the Limitations of Patient-Reported Outcome Measures. *J Orthop Sports Phys Ther*.
342   2021;1-11.
343   18.   Craske MG, Treanor M, Conway CC, Zbozinek T, Vervliet B. Maximizing exposure therapy: an
344   inhibitory learning approach. *Behav Res Ther*. 2014;58:10-23.

345 19. Crombez G, Eccleston C, Van Damme S, Vlaeyen JW, Karoly P. Fear-avoidance model of
346   chronic pain: the next generation. *Clin J Pain*. 2012;28:475-483.
347 20. Culver NC, Vervliet B, Craske MG. Compound extinction: Using the Rescorla–Wagner model
348   to maximize exposure therapy effects for anxiety disorders. *Clinical Psychological Science*.
349   2015;3:335-348.
350 21. De Baets L, Matheve T, Meeus M, Struyf F, Timmermans A. The influence of cognitions,
351   emotions and behavioral factors on treatment outcomes in musculoskeletal shoulder pain: a
352   systematic review. *Clin Rehabil*. 2019;33:980-991.
353 22. De Baets L, Matheve T, Timmermans A. The Association Between Fear of Movement, Pain
354   Catastrophizing, Pain Anxiety, and Protective Motor Behavior in Persons With Peripheral
355   Joint Conditions of a Musculoskeletal Origin: A Systematic Review. *Am J Phys Med Rehabil*.
356   2020;99:941-949.
357 23. den Hollander M, Smeets R, van Meulenbroek T, van Laake-Geelen CCM, Baadjou VA,
358   Timmers I. Exposure in Vivo as a Treatment Approach to Target Pain-Related Fear: Theory
359   and New Insights From Research and Clinical Practice. *Phys Ther*. 2022;102:
360 24. Falla D, Gallina A. New insights into pain-related changes in muscle activation revealed by
361   high-density surface electromyography. *J Electromyogr Kinesiol*. 2020;52:102422.
362 25. Falla D, Gizzi L, Tschapek M, Erlenwein J, Petzke F. Reduced task-induced variations in the
363   distribution of activity across back muscle regions in individuals with low back pain. *Pain*.
364   2014;155:944-953.
365 26. Gatchel RJ, Peng YB, Peters ML, Fuchs PN, Turk DC. The biopsychosocial approach to chronic
366   pain: scientific advances and future directions. *Psychol Bull*. 2007;133:581-624.
367 27. Gatzounis R, den Hollander M, Meulders A. Optimizing Long-term Outcomes of Exposure for
368   Chronic Primary Pain from the Lens of Learning Theory. *J Pain*. 2021;22:1315-1327.
369 28. Gizzi L, Röhrle O, Petzke F, Falla D. People with low back pain show reduced movement
370   complexity during their most active daily tasks. *Eur J Pain*. 2019;23:410-418.
371 29. Glogan E, Gatzounis R, Bennett MP, Holthausen K, Meulders A. Generalization of pain-
372   related avoidance behavior based on de novo categorical knowledge. *Pain*. 2022;
373 30. Glombiewski JA, Holzapfel S, Riecke J, et al. Exposure and CBT for chronic back pain: An RCT
374   on differential efficacy and optimal length of treatment. *J Consult Clin Psychol*. 2018;86:533-
375   545.
376 31. Glombiewski JA, Riecke J, Holzapfel S, et al. Do patients with chronic pain show autonomic
377   arousal when confronted with feared movements? An experimental investigation of the
378   fear-avoidance model. *Pain*. 2015;156:547-554.
379 32. Hasenbring MI, Verbunt JA. Fear-avoidance and endurance-related responses to pain: new
380   models of behavior and their consequences for clinical practice. *Clin J Pain*. 2010;26:747-
381   753.
382 33. Hodges PW, Smeets RJ. Interaction between pain, movement, and physical activity: short-
383   term benefits, long-term consequences, and targets for treatment. *Clin J Pain*. 2015;31:97-
384   107.
385 34. Holzapfel S, Schemer L, Riecke J, Glombiewski JA. Behavioral Test (BAT-Back): Preliminary
386   Evidence for a Successful Predictor of Treatment Outcome After Exposure Treatment for
387   Chronic Low Back Pain. *Clin J Pain*. 2021;37:265-269.
388 35. Ippersiel P, Teoli A, Wideman TH, Preuss RA, Robbins SM. The Relationship Between Pain-
389   Related Threat and Motor Behavior in Nonspecific Low Back Pain: A Systematic Review and
390   Meta-Analysis. *Phys Ther*. 2022;102:
391 36. Knowles KA, Olatunji BO. Enhancing Inhibitory Learning: The Utility of Variability in Exposure.
392   *Cogn Behav Pract*. 2019;26:186-200.
393 37. Lee H, Hübscher M, Moseley GL, et al. How does pain lead to disability? A systematic review
394   and meta-analysis of mediation studies in people with back and neck pain. *Pain*.
395   2015;156:988-997.

396 38. Leeuw M, Goossens M, van Breukelen GJP, et al. Exposure in vivo versus operant graded
397   activity in chronic low back pain patients: results of a randomized controlled trial. *Pain*.
398   2008;138:192-207.
399 39. Leeuw M, Goossens ME, van Breukelen GJ, Boersma K, Vlaeyen JW. Measuring perceived
400   harmfulness of physical activities in patients with chronic low back pain: the Photograph
401   Series of Daily Activities--short electronic version. *J Pain*. 2007;8:840-849.
402 40. Leeuw M, Goossens ME, van Breukelen GJ, et al. Exposure in vivo versus operant graded
403   activity in chronic low back pain patients: results of a randomized controlled trial. *Pain*.
404   2008;138:192-207.
405 41. Lewis J, O'Sullivan P. Is it time to reframe how we care for people with non-traumatic
406   musculoskeletal pain? *Br J Sports Med*. 2018;52:1543-1544.
407 42. Lin I, Wiles L, Waller R, et al. What does best practice care for musculoskeletal pain look like?
408   Eleven consistent recommendations from high-quality clinical practice guidelines: systematic
409   review. *Br J Sports Med*. 2020;54:79-86.
410 43. Lovibond PF, Mitchell CJ, Minard E, Brady A, Menzies RG. Safety behaviours preserve threat
411   beliefs: Protection from extinction of human fear conditioning by an avoidance response.
412   *Behaviour Research and Therapy*. 2009;47:716-720.
413 44. Luque-Suarez A, Martinez-Calderon J, Falla D. Role of kinesiophobia on pain, disability and
414   quality of life in people suffering from chronic musculoskeletal pain: a systematic review. *Br J
415   Sports Med*. 2019;53:554-559.
416 45. Matheve T, De Baets L, Bogaerts K, Timmermans A. Lumbar range of motion in chronic low
417   back pain is predicted by task-specific, but not by general measures of pain-related fear. *Eur
418   J Pain*. 2019;23:1171-1184.
419 46. Matheve T, Janssens L, Goossens N, et al. The relationship between pain-related
420   psychological factors and maximal physical performance in low back pain: a systematic
421   review and meta-analysis. *J Pain*. 2022;
422 47. Meulders A. Fear in the context of pain: Lessons learned from 100 years of fear conditioning
423   research. *Behaviour Research and Therapy*. 2020;131:103635.
424 48. Meulders A. From fear of movement-related pain and avoidance to chronic pain disability: a
425   state-of-the-art review. *Current Opinion in Behavioral Sciences*. 2019;26:130-136.
426 49. Meulders A, Van Daele T, Volders S, Vlaeyen JW. The use of safety-seeking behavior in
427   exposure-based treatments for fear and anxiety: Benefit or burden? A meta-analytic review.
428   *Clin Psychol Rev*. 2016;45:144-156.
429 50. Morley S. Psychology of pain. *Br J Anaesth*. 2008;101:25-31.
430 51. Mowrer OH. *Learning theory and behavior.* John Wiley & Sons Inc; 1960.
431 52. O'Sullivan P. Diagnosis and classification of chronic low back pain disorders: maladaptive
432   movement and motor control impairments as underlying mechanism. *Man Ther*.
433   2005;10:242-255.
434 53. O'Sullivan PB, Caneiro JP, O'Keeffe M, et al. Cognitive Functional Therapy: An Integrated
435   Behavioral Approach for the Targeted Management of Disabling Low Back Pain. *Phys Ther*.
436   2018;98:408-423.
437 54. Sanderson A, Cescon C, Heneghan NR, et al. People With Low Back Pain Display a Different
438   Distribution of Erector Spinae Activity During a Singular Mono-Planar Lifting Task. *Front
439   Sports Act Living*. 2019;1:65.
440 55. Sanderson A, Martinez-Valdes E, Heneghan NR, Murillo C, Rushton A, Falla D. Variation in
441   the spatial distribution of erector spinae activity during a lumbar endurance task in people
442   with low back pain. *J Anat*. 2019;234:532-542.
443 56. Sharpe L, Todd J, Scott A, Gatzounis R, Menzies RE, Meulders A. Safety behaviours or safety
444   precautions? The role of subtle avoidance in anxiety disorders in the context of chronic
445   physical illness. *Clin Psychol Rev*. 2022;92:102126.

446 57. Sheikhzadeh A, Wertli MM, Weiner SS, Rasmussen-Barr E, Weiser S. Do psychological factors
447   affect outcomes in musculoskeletal shoulder disorders? A systematic review. *BMC*
448   *Musculoskelet Disord*. 2021;22:560.
449 58. Sleijser-Koehorst MLS, Bijker L, Cuijpers P, Scholten-Peeters GGM, Coppieters MW. Preferred
450   self-administered questionnaires to assess fear of movement, coping, self-efficacy, and
451   catastrophizing in patients with musculoskeletal pain-A modified Delphi study. *Pain*.
452   2019;160:600-606.
453 59. Van Damme S, Kindermans H. A self-regulation perspective on avoidance and persistence
454   behavior in chronic pain: new theories, new challenges? *Clin J Pain*. 2015;31:115-122.
455 60. Van Damme S, Legrain V, Vogt J, Crombez G. Keeping pain in mind: a motivational account of
456   attention to pain. *Neurosci Biobehav Rev*. 2010;34:204-213.
457 61. Van Damme S, Van Ryckeghem DML, Wyffels F, Van Hulle L, Crombez G. No pain no gain?
458   Pursuing a competing goal inhibits avoidance behavior. *PAIN®*. 2012;153:800-804.
459 62. van Dieën JH, Flor H, Hodges PW. Low-Back Pain Patients Learn to Adapt Motor Behavior
460   With Adverse Secondary Consequences. *Exerc Sport Sci Rev*. 2017;45:223-229.
461 63. van Uijen SL, Dalmaijer ES, van den Hout MA, Engelhard IM. Do safety behaviors preserve
462   threat expectancy? *Journal of Experimental Psychopathology*. 2018;9:2043808718804430.
463 64. van Vliet CM, Meulders A, Vancleef LMG, Vlaeyen JWS. The Opportunity to Avoid Pain May
464   Paradoxically Increase Fear. *J Pain*. 2018;19:1222-1230.
465 65. Vlaeyen JW, Morley S, Linton SJ, Boersma K, de Jong J. *Pain-related fear: Exposure-based*
466   *treatment of chronic pain*. IASP press; 2012.
467 66. Volders S, Meulders A, De Peuter S, Vervliet B, Vlaeyen JW. Safety behavior can hamper the
468   extinction of fear of movement-related pain: an experimental investigation in healthy
469   participants. *Behav Res Ther*. 2012;50:735-746.
470 67. Volders S, Meulders A, De Peuter S, Vlaeyen JW. The Reduction of Fear of Movement-related
471   Pain: Does Motivational Context Matter? *Clin J Pain*. 2015;31:933-945.
472 68. Weisman JS, Rodebaugh TL. Exposure therapy augmentation: A review and extension of
473   techniques informed by an inhibitory learning approach. *Clinical psychology review*.
474   2018;59:41-51.
475 69. Wernli K, O'Sullivan P, Smith A, Campbell A, Kent P. Movement, posture and low back pain.
476   How do they relate? A replicated single-case design in 12 people with persistent, disabling
477   low back pain. *European journal of pain*. 2020;24:1831-1849.
478 70. Wernli K, Smith A, Coll F, Campbell A, Kent P, O'Sullivan P. From protection to non-
479   protection: A mixed methods study investigating movement, posture and recovery from
480   disabling low back pain. *Eur J Pain*. 2022;
481 71. Wernli K, Tan J-S, O'Sullivan P, Smith A, Campbell A, Kent P. The Relationship Between
482   Changes in Movement and Changes in Low Back Pain: A Systematic Review of Single-Case
483   Designs. *JOSPT Cases*. 2021;1:199-219.
484 72. Wernli K, Tan JS, O'Sullivan P, Smith A, Campbell A, Kent P. Does Movement Change When
485   Low Back Pain Changes? A Systematic Review. *J Orthop Sports Phys Ther*. 2020;50:664-670.
486 73. Woods MP, Asmundson GJG. Evaluating the efficacy of graded in vivo exposure for the
487   treatment of fear in patients with chronic back pain: a randomized controlled clinical trial.
488   *Pain*. 2008;136:271-280.

489

490 **Figures**

491 **FIGURE 1.** Person-centred approach to evaluating fear of movement and avoidance behaviour

492   Legend: Person-centred approach to the evaluation of fear of movement and avoidance behaviour,

493   including the patient interview, the behavioural assessment, and the item-based analysis of self-report

494   measures. Interview prompts elicit individual beliefs regarding specific movements, related emotional

495   responses, together with individual contextual and motivational aspects related to fear of movement

496   and avoidance behaviour. By assessing the patient in this all-encompassing way, discrepancies

497   between and within the outcomes of the interview, self-report measures and behavioural assessment

498   can be identified and interpreted. The question marks refer to the potential discrepant outcomes

499   between the evaluation's components. Icons by Juicy Fish, Justine Blake, Kylie Hana, Cuputi, Gan

500   Khoon Lay from the Noun Project.

501

502   **FIGURE 2.** Observing lumbar flexion during habitual sitting posture (A), maximally slouched sitting

503   posture (B), and maximal forward flexion in standing (C) during the behavioural assessment.

504   Legend: Eva shows an upright habitual sitting position (A). In maximally slouched sitting, her lumbar

505   posture remains unchanged and only increased thoracic flexion is observed (B). The same pattern is

506   observed during forward bending where Eva does not flex her lumbar spine and only bends at the hips

507   and thoracic spine. Kinematic assessment revealed that Eva's lumbar range of motion during maximal

508   spinal flexion and lifting a crate (not shown) was 10.3° and 7.0°, respectively. Reference values of

509   lumbar flexion range of motion during these tasks are 37.4° (maximal flexion) and 27.5° (lifting a crate)

510   for persons with chronic nonspecific low back pain, and 46.4° (maximal flexion) and 37.7° (lifting a

511   crate) for pain-free persons[45]. Both in the habitual sitting position and the maximally slouched

512   position, over-activity of the lumbar extensor muscles is observed by palpation (A, B). A strong co-

513   activation of the lumbar extensor muscles and abdominal muscles is identified on palpation during

514   maximal flexion in standing and while lifting (C).

TABLE 1. Clinical case: Eva's story

Eva is a 42-year old woman, with a senior management position in an international company. Eva's job is highly demanding and stressful.

Eva's low back pain started four years ago. She cannot recall a specific event that triggered this episode of low back pain, but she believes that it is related to her sedentary job. A few weeks after the onset of her low back pain, Eva had an MRI, which showed a herniated disc at L4/L5 without nerve root compression. Since the onset of her back problems, Eva has received physical therapy on multiple occasions, which consisted of manual therapy and motor control exercises.

Currently, Eva has pain across the lower back region, without leg symptoms. The pain is constant, moderate to severe (mean pain score= 6/10), and aggravated mainly by flexion-related activities, such as lifting shopping bags and working in her garden. Eva experiences high levels of pain-related disability, impacting her leisure time activities and playtime with her kids. This is evident from her high score on the Roland Morris Disability Questionnaire (17/24).

Eva's low scores on self-reported measures of fear of movement and avoidance behaviour indicate low levels of fear of movement (31.8/100 on the Photograph Series of Daily Activities (PHODA) – Short electronic Version (PHODA-SeV), 27/68 on the Tampa Scale for Kinesiophobia (TSK) and 29/96 on the Fear Avoidance Beliefs Questionnaire (FABQ)). Eva is concerned that some of her symptoms during bending reflect damage in her back, and she avoids lumbar flexion (**FIGURE 2**). Taken together, the low levels of fear based on the self-report measures do not correspond with the information she provided during the in-depth interview and behavioural assessment.

515

516

TABLE 2. Quotes from Eva that help clinicians understand Eva's narrative and specific context regarding her fear of movement and avoidance behaviour	
Quote 1	*"….pain definitely plays a role, but then also, sometimes it just doesn't feel right… I have the feeling that, when I bend, there is some friction in my back, a grinding feeling… Like some things are rubbing against each other."; "I feel that something in my back is out of place… that's why I think that there is some damage and why I try to avoid bending my back. Pain tells you something's wrong… that something bad can happen".*
Quote 2	*"… after I had my MRI and I discussed it with the specialist, he told me to be careful because I had this disc bulge … He said to be careful not to make it worse"; "It is generally known that a hernia is a very serious problem. I mean, once you've got a hernia, that's for life. You hear a lot of stories about it from friends."*
Quote 3	*"I know that exercising is necessary for my back. I sit for many hours a day, even in weekends, that's really not good for my back"; "I have been doing Pilates for 2 years. I like it because I can control the exercises very well, so they do not cause pain and nothing bad can happen. I continuously check the position of my back, you know, to keep it in a good position without bending my back"… "I cycle indoors in the gym, on a stationary bike. I like that as I know nothing unexpectedly will happen…I make sure I put my steer in a really high position, so I don't have to bend my back... that's better for me and for my back."; "I can't play football with my son or do some dancing with my daughter because… it is a lot of unexpected and fast movements... that is too dangerous and would give me a lot of pain."*
Quote 4	*"Cycling… I am doing this together with my husband, and it is the only activity that we actually do together, without the kids … And we go for a drink afterwards. That's why I don't like to give up on this... I think it's more important for us that we just continue this, even though I know I'm going to have pain afterwards."*

	"Cleaning the house, I really don't like it… It also hurts my back. I'm so glad we found someone to clean our house."
Quote 5	*"I sit too much at work and I don't move around enough …that's not good for my back";* *"I need to be there to manage everything, and if I'm not there, who will do it then?"; "I also do not want to stop working, I feel so involved in the organization. I don't want people to wait for me. I feel responsible if things don't move forward.".*

517

518

TABLE 3. The influence of activity characteristics on Eva's harm-expectancies on different Photograph Series of Daily Activities – Short electronic Version (PHODA-SeV) items

The activities 'picking up shoes with a bent back' (score 45/100) and 'unloading a dishwasher' (score 44/100) are scored lower than 'mopping the floor' (score 62/100). Although none of these tasks involve heavy weights, Eva associates the latter activity with a *longer* and *more continuous spinal flexion* position, which is the reason she perceives it as more harmful.

In contrast, 'lifting a pot with a bent back' is scored very harmful (score 88/100) because of the load *in a flexed position*. Eva says she would not be able to lift the pot as she believes her back would buckle. Related to this, the activity 'taking a heavy box from a shelf above head' (score 61/100) is perceived as more harmful than the activity 'drilling a hole above head' (score 28/100), although these activities are both performed in a spinal extension position. For Eva, the *weight* of the box, which she perceives as much heavier than that of the drilling machine, is the reason to score this activity as harmful. This shows that back posture, load and duration of an activity are characteristics that influence the perceived threat for Eva.

519

TABLE 4. Limitations of self-report measures assessing fear of movement and avoidance behaviour
General self-report measures, such as the Tampa Scale for Kinesiophobia (TSK) or the Fear-Avoidance Beliefs Questionnaire (FABQ)[58] have important limitations for assessing fear of movement and avoidance behaviour [5, 17]. First, they only provide a generic perspective on a person's fear of movement as they do not evaluate fear related to specific movements or activities[45], thereby discounting potentially important contextual and motivational factors[60]. Some self-report measures do evaluate the perceived harmfulness of specific activities (e.g., the PHODA-SeV or the Avoidance of Daily Activities Photo Shoulder Scale)[2, 39], yet, they only tap into a person's cognitions superficially, not considering motivational and contextual factors[59]. Second, general self-report measures do not assess the person's actual avoidance behaviour, and recent systematic reviews indicate that self-report measures are only weakly associated with the actual behaviour[14, 22, 35, 45]. Finally, the currently used self-report measures make no distinction between expectations about harm, pain, or functional limitations[9-11], while this distinction significantly affects treatment choices.

520

521

TABLE 5. Safety behaviour as source of ongoing peripheral nociceptive input

While safety behaviour might initially be adaptive by temporarily unloading painful or damaged tissues, they might have negative consequences in the long-term as they can lead to sensorimotor adaptations in the musculoskeletal system[62]. These sensorimotor adaptations may induce (continuous) nociceptive input, by inappropriately loading the musculoskeletal system[25, 28, 54]. Examples of sensorimotor adaptations are sustained muscle co-activation, increased movement rigidity and decreased variability in the within and between muscle activation distribution[25, 69, 71, 72]. These stereotypical movement and muscle activation patterns may cause greater net local muscle activity[24, 25] and increased compressive loads on the spine, resulting in peripheral nociceptive input. This way, pain can persist even though the original source of nociception may no longer be present in persons with chronic nonspecific musculoskeletal pain. In turn, pain reinforces the notion that the body part needs to be protected which leads to further tension and loading, initiating a vicious cycle of fear, protection, pain and disability.

522

523

TABLE 6. Eva's case demonstrates that maximising expectancy violation during exposure is essential to enhance extinction learning[18, 20, 27]

Instead of exposing Eva to gradually increasing feared activities to achieve habituation (i.e., fear reduction), we immediately expose Eva to highly fearful activities. We expected that the catastrophe is more likely to occur during a highly fearful task; the expectancy violation will be stronger and extinction learning will be enhanced. Instead of asking Eva to lift a light object with a bent back and to gradually increase the weight, we asked her to lift a heavy object. Eva fears and avoids different types of activities (e.g., spinal flexion and sudden movements): we can initially expose Eva to these feared activities separately, after which these can be combined (e.g., sudden spinal flexion)[27]. By combining both types of activities, it hypothesised that the expected outcome is much worse as for the activities separately. If no catastrophic event happens when performing the compound activity, expectancy violation will be substantial.[20]

From the item-based analysis of the PHODA-SeV, it became clear that the duration of the task and the load of an object played a role in Eva's perception of harmfulness. As such, Eva should also be exposed to continued flexion positions and heavy load handling, that latter also during non-flexion positions or movements of the spine. Consider duration and load characteristics when exposing Eva to compound activities. Eva also indicated that the presence of the therapist made her feel safe. Therefore, exposure should not be confined to this safe context, but Eva should also be confronted with the feared activities in different contexts (e.g., via home assignments). Using various contexts can also enhance generalisation of extinction, which is an important treatment aim. This generalisation may also be increased by using variations of the same activity during exposure, to stimulate variable movement patterns. For lifting, Eva can use real life objects of different shapes and sizes, perform lifting activities with one or both hands, introduce rotational movements, or lift objects that are positioned close by or far away. From an inhibitory learning perspective, safety

behaviours should not be allowed during exposure, since the non-occurrence of the catastrophic event during exposure will be attributed to these safety behaviours. Consequently, no expectancy violation and extinction learning will occur.

Eva's unhelpful safety behaviours are to keep her back straight and to continuously co-activate her abdominal and back muscles. Specific focus during exposure on spinal flexion and the conscious relaxation of these muscles might help disconfirm her harm-expectancies[6]. Specifically addressing these sensorimotor adaptations may also reduce the peripheral nociceptive input that may partially be responsible for her persistent pain[25, 28, 54](see Table 3).

524

525

Pain narrative

Item-based analysis of self-report measures:

In-depth item analysis. Discussing answers to specific items to elicit additional information to patient interview, which may guide behavioural experiments

Patient interview:

Self-report of the pain-experience during specific activities, linked to personal goals. Questioning beliefs related to such activities.

Individual underlying beliefs

Person-centred approach to the evaluation of fear of movement and avoidance behaviour

Contextual aspects

Motivational aspects

Behavioural assessment:

By using interview prompts, beliefs regarding specific movements and related emotional response are elicited. Identification of individual safety behaviours.

Lumbar flexion = 7.0°

A	B	C
habitual sitting posture	maximally slouched sitting	maximal flexion in standing

Supplementary material 1.

General information on the self-report measures and Eva's individual items scores on the self-report measures, with additional remarks on the individual item analysis when relevant.

Photograph Series of Daily Activities—Short Electronic Version
The Photograph Series of Daily Activities—Short Electronic Version (PHODA-SeV) is a measure of perceived harmfulness of specific physical activities[3]. Forty consecutive pictures of daily life activities are shown on a computer screen. Participants are asked to imagine themselves performing the activities and to indicate to which extent they think the activities are harmful to their back on a 0 to 100 scale (0 = not harmful at all, 100 = extremely harmful). A total score (0–100) is calculated by averaging the scores of the 40 pictures.

Eva's total score on the PHODA-SeV is 31.8/100, indicating a low level of perceived harmfulness. When assessing more task-specific, and calculating her score only based on flexion-related activities, Eva scores 64.8/100, indicating a high level of perceived harmfulness. In contrast, calculating her score for non-flexion-related activities, she has a score of 23.6/100.

Item scores in order of perceived harmfulness

Short photograph label (photo number)	score	order	flexion?
Falling backwards (38)	91	1	
Lifting pot, bent back (3)	88	2	x
Shovelling soil (1)	81	3	x
Lifting toddler from cot (31)	72	4	x
Lifting beer crate, bent back (10)	67	5	x
Mopping floor (17)	62	6	x
Taking heavy box from shelf above head (21)	61	7	
Lifting basket, walking up stairs (9)	60	8	
Carrying child on hip (32)	59	9	
Vacuum cleaning (16)	59	10	x
Mowing lawn (39)	57	11	
Picking up shoes, bent back (4)	45	12	x
Clearing out dishwasher (14)	44	13	x
Carrying rubbish bag, one hand (13)	36	14	
Carrying shopping bag, one hand (11)	34	15	
Carrying two shopping bags, both hands (12)	32	16	
Doing dishes (33)	32	17	
Getting out of bed (26)	30	18	
Drilling hole above head (40)	28	19	
Lifting pot, squatting (2)	26	20	
Trampoline jumping (22)	23	21	
Making bed (25)	23	22	
Leg stretching (18)	22	23	

Short photograph label (photo number)	score	order
Cleaning windows above head (29)	20	24
Taking box from cupboard (15)	18	25
Back twisting (19)	15	26
Cycling from kerb (36)	15	27
Rope skipping (23)	12	28
Abdominal exercises (24)	11	29
Back bending (20)	10	30
Picking up shoes, squatting (5)	8	31
Ironing while standing (7)	8	32
Cycling, looking aside (37)	7	33
Taking book, twisted back (6)	6	34
Running through forest (34)	4	35
Riding bike bumpy street (30)	3	36
Ironing while sitting (8)	2	37
Walking up stairs (27)	2	38
Walking down stairs (28)	0	39
Walking through forest (35)	0	40
Mean score	**31.8**	

Item scores flexion-related activities in order of perceived harmfulness

Short photograph label (photo number)	score	order	flexion?
Lifting pot, bent back (3)	88	2	x
Shovelling soil (1)	81	3	x
Lifting toddler from cot (31)	72	4	x
Lifting beer crate, bent back (10)	67	5	x
Mopping floor (17)	62	6	x
Vacuum cleaning (16)	59	10	x
Picking up shoes, bent back (4)	45	12	x
Clearing out dishwasher (14)	44	13	x
Mean score Flexion	**64.8**		

PHODA-SeV item scores non-flexion-related activities in order of perceived harmfulness

Short photograph label (photo number)	score	order	flexion?
Falling backwards (38)	91	1	
Taking heavy box from shelf above head (21)	61	7	
Lifting basket, walking up stairs (9)	60	8	
Carrying child on hip (32)	59	9	
Mowing lawn (39)	57	11	
Carrying rubbish bag, one hand (13)	36	14	
Carrying shopping bag, one hand (11)	34	15	
Carrying two shopping bags, both hands (12)	32	16	
Doing dishes (33)	32	17	
Getting out of bed (26)	30	18	
Drilling hole above head (40)	28	19	

Lifting pot, squatting (2)	26	20
Trampoline jumping (22)	23	21
Making bed (25)	23	22
Leg stretching (18)	22	23
Cleaning windows above head (29)	20	24
Taking box from cupboard (15)	18	25
Back twisting (19)	15	26
Cycling from kerb (36)	15	27
Rope skipping (23)	12	28
Abdominal exercises (24)	11	29
Back bending (20)	10	30
Picking up shoes, squatting (5)	8	31
Ironing while standing (7)	8	32
Cycling, looking aside (37)	7	33
Taking book, twisted back (6)	6	34
Running through forest (34)	4	35
Riding bike bumpy street (30)	3	36
Ironing while sitting (8)	2	37
Walking up stairs (27)	2	38
Walking down stairs (28)	0	39
Walking through forest (35)	0	40
Mean Score	**23.6**	

Tampa Scale for Kinesiophobia

The Tampa Scale for Kinesiophobia (TSK) is a questionnaire containing 17 items to assess fear of movement/re-injury due to physical activity[6]. The total score ranges between 17 and 68, where 17 means no fear of movement, 68 means severe no fear of movement, and score ± 37 indicates there is no fear of movement. For patients with CLBP, two subscales can be discerned in the TSK. The activity avoidance subscale (TSK-AA, items 1, 2, 10, 13, 15, and 17) specifically measures activity avoidance and fear of re-injury, whereas the Somatic Focus subscale (TSK-SF, items 3, 11, 6, 7, 5) assesses to which extent patients believe that their pain can be attributed to a serious underlying medical problem[2].

Eva's total score on the TSK is 27/68, indicating a low level of fear of movement. She scores 11/32 on the TSK-AA and 9/20 on the TSK-SF.

		Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
1	I'm afraid that I might injury myself if I exercise	**1**	2	3	4
2	If I were to try to overcome it, my pain would increase	**1**	2	3	4
3	My body is telling me I have something dangerously wrong	1	**2**	3	4
4*	My pain would probably be relieved if I were to exercise	1	2	3	**4**
5	People aren't taking my medical condition seriously enough	1	**2**	3	4
6	My accident has put my body at risk for the rest of my life	**1**	2	3	4
7	Pain always means I have injured my body	1	2	**3**	4
8*	Just because something aggravates my pain does not mean it is dangerous	1	2	3	**4**
9	I am afraid that I might injure myself accidentally	1	2	**3**	4
10	Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening	**1**	2	3	4
11	I wouldn't have this much pain if there weren't something potentially dangerous going on in my body	**1**	2	3	4
12*	Although my condition is painful, I would be better off if I were physically active	1	2	3	**4**
13	Pain lets me know when to stop exercising so that I don't injure	1	**2**	3	4
14	It's really not safe for a person with a condition like mine to be physically active	**1**	2	3	4
15	I can't do all the things normal people do because it's too easy for me to get injured	**1**	2	3	4
16*	Even though something is causing me a lot of pain, I don't think it's actually dangerous	**1**	2	3	4
17	No one should have to exercise when he/she is in pain	**1**	2	3	4

*Scores are reversed when total score is calculated

Additional remarks regarding Eva's TSK's total and relevant items' scores:

Eva's low TSK-total score corresponds to Eva's story, in which she indicates that she 'knows' that activity and exercise are good for a healthy back. This is also evident from her low scores on the TSK items assessing her attitude regarding bodily exercises, indicating no fear to exercise and that she beliefs exercising is good for her back (See Appendix 1, e.g. items 1, 4, 12, 13, 14, 17).

There seems to be some inconsistency in Eva's answers on the items 9 ('I am afraid that I might injure myself accidentally', score 3: agree) and 10 ('simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening', score 1: strongly disagree). When asking how she perceives the difference between both items, she associates 'injuring oneself accidentally' (item 9) with sudden, uncontrollable movements which, in her perception, might cause harm. However, Eva explains that she does not associate 'unnecessary movements' (item 10) with these sudden, uncontrollable movements.

Apart from the motivational perspective which is not questioned in the TSK[1, 4], an important reason for the discrepancy between Eva's (avoidant) behaviour and her score on the TSK, is that the TSK items refer to 'exercises' or 'activity', rather than to specific activities. However, Eva considers exercising or being active in general as beneficial, although she is fearful of particular activities.

Fear-avoidance Beliefs Questionnaire

The Fear-avoidance Beliefs Questionnaire (FABQ) is a 16-item scale investigating fear-avoidance beliefs. Two subscales are defined: the FABQ-physical activity subscale (4 items, item 2, 3, 4, 5) and FABQ-Work subscale (7 items, item 6, 7, 9, 10, 11, 12, 15).[5] Each item is scored on a 7-point Likert scale with a score ranging from zero ("completely disagree") to six ("completely agree"). Higher scores indicate higher levels of fear avoidance beliefs.

Eva's total FABQ score is 29/96, her subscores on the FABQ-physical activity and work subscale are 10/24 and 18/42, respectively.

		Completely disagree			Unsure			Completely agree
1	My pain was caused by physical activity	0	**1**	2	3	4	5	6
2	Physical activity makes my pain worse	0	1	2	3	4	**5**	6
3	Physical activity might harm my back	0	1	**2**	3	4	5	6
4	I should not do physical activities which (might) make my pain worse	0	1	**2**	3	4	5	6
5	I cannot do physical activities which (might) make my pain worse	0	**1**	2	3	4	5	6

The following statements are about how your normal work affects or would affect your back pain.

		Completely disagree			Unsure			Completely agree
6	My pain was caused by my work or by an accident at work	0	1	2	**3**	4	5	6
7	My work aggravated my pain	0	1	2	3	4	**5**	6
8	I have a claim for compensation for my pain	**0**	1	2	3	4	5	6
9	My work is too heavy for me	0	1	**2**	3	4	5	6
10	My work makes or would make my pain worse	0	1	2	3	4	**5**	6
11	My work might harm my back	0	1	2	**3**	4	5	6
12	I should not do my normal work with my present pain	**0**	1	2	3	4	5	6
13	I cannot do my normal work with my present pain	**0**	1	2	3	4	5	6

14	I cannot do my normal work until my pain is treated	**0**	1	2	3	4	5	6
15	I do not think that I will be back to my normal work within 3 months	**0**	1	2	3	4	5	6
16	I do not think that I will ever be able to go back to that work	**0**	1	2	3	4	5	6

Additional remarks:

From the FABQ-work score, it is clear that Eva thinks that her pain is caused and increased in intensity by her job (items 6, 7, 10, 11). In contrast, scores on the items 13 to 16 indicate that she feels very able to perform her job. She furthermore indicates that she strongly disagrees that she should discontinue her tasks at work due to her pain. These scores are in line with Eva's story regarding her work-activities and her idea on the origin of her pain.

Apart from the motivational perspective which is not questioned in the TSK[1, 4], an important reason for the discrepancy between Eva's (avoidant) behaviour and her score on the FABQ-PA, is that the FABQ-PA items refer to 'physical activity', rather than to specific activities. However, Eva considers being active in general as beneficial, although she is fearful of particular activities.

References

1. Claes N, Vlaeyen JWS, Crombez G. Pain in context: Cues predicting a reward decrease fear of movement related pain and avoidance behavior. *Behav Res Ther*. 2016;84:35-44.
2. Goubert L, Crombez G, Van Damme S, Vlaeyen JW, Bijttebier P, Roelofs J. Confirmatory factor analysis of the Tampa Scale for Kinesiophobia: invariant two-factor model across low back pain patients and fibromyalgia patients. *Clin J Pain*. 2004;20:103-110.
3. Leeuw M, Goossens ME, van Breukelen GJ, Boersma K, Vlaeyen JW. Measuring perceived harmfulness of physical activities in patients with chronic low back pain: the Photograph Series of Daily Activities--short electronic version. *J Pain*. 2007;8:840-849.
4. Van Damme S, Van Ryckeghem DML, Wyffels F, Van Hulle L, Crombez G. No pain no gain? Pursuing a competing goal inhibits avoidance behavior. *PAIN®*. 2012;153:800-804.
5. Vendrig A, Deutz, P., & Vink, I. . Nederlandse vertaling en bewerking van de Fear Avoidance Beliefs Questionnaire. . *Nederlands Tijdschrift voor Pijn en Pijnbestrijding*. 1998;18:11-15.
6. Vlaeyen JWS, Kole-Snijders AMJ, Boeren RGB, van Eek H. Fear of movement/(re)injury in chronic low back pain and its relation to behavioral performance. *Pain*. 1995;62:363-372.

SUPPLEMENTARY MATERIAL 2.

TABLE 1. Theoretical frameworks that underpin the person-centred approach to the evaluation of fear of movement and avoidance behaviour

FEAR ACQUISITION[3, 4]

Fear of movement can be acquired via direct experience, instructional learning, observational learning or a combination of the previous. These forms of fear acquisition are examples of Pavlovian conditioning.

Direct experience	Pain is an alarm signal of bodily harm and it elicits defensive responses, such as fear and avoidance behaviour. When a person experiences pain (unconditioned stimulus; US) during an initially neutral movement (e.g., lifting with a bent back; conditioned stimulus; CS), this person will start to associate the movement with pain. As a consequence, confrontation with the initially neutral movement will also elicit fear and avoidance (conditioned responses; CR).
Instructional learning	Fear can be acquired via (verbal or written) instructions or information received from various sources, such as significant others, the media or health care providers. For example, when a health care provider instructs a patient to keep a straight back while lifting because lifting with a bent back may damage the spine, this patient may develop a fear for lifting with a bent back and start avoiding this activity.
Observational learning	We can learn by observing other people's behaviour when they are confronted with pain. For example, when we see someone experiencing pain during a particular movement, we may learn that this movement is dangerous and should be avoided.

AVOIDANCE BEHAVIOUR[3, 4]

Avoidance behaviour can range from very *subtle behavioural adaptations* to *complete avoidance*. Depending on the situation, avoidance behaviour can be considered *adaptive* or *overprotective*. Furthermore, avoidance behaviour might *generalise* to other activities.

Behavioural adaptations are shaped by the consequences of the shown behaviour. For example, based on operant conditioning, behavioural adaptations may be reinforced or maintained due to the reduction of fear/pain (negative reinforcement) and/or increase in activity participation (positive reinforcement) that result from the adapted behaviour. Therefore, behavioural adaptations might be considered functional. However, behavioural adaptations might also have negative consequences, for example, by overloading musculoskeletal structures or by misattributing safety to the adapted behaviour. This is the case for *safety behaviours*.

Complete avoidance behaviour	A person may completely avoid a certain activity. For example: never lifting heavy objects because it may damage the spine or never running in a forest because the fear of an ankle sprain.
Subtle behavioural adaptations – safety behaviours	A person may not completely avoid an activity, but only perform it with behavioural adaptations. Regarding fear of movement, these behavioural adaptations often pertain to movement-related behaviour. Examples of such adaptations are: no or less movement at the painful area (e.g., keeping the back straight), compensatory movement in non-painful body regions (e.g., bending the knees, rotating at the hips), increased co-contraction, reduced movement variability, slower movements or taking a larger base of support. People may consciously adapt their behaviour, but it is also possible that persons are not aware of these adaptations (e.g., a person might not be aware of exaggerated co-contraction).
	Safety behaviours are (subtle) behavioural adaptations that intend to prevent the expected negative outcome from occurring (prevention of

	harm/damage). For example, if a person is convinced that lifting with a bent back will cause the intervertebral disc to pop out, this person may only lift with a straight back to prevent the feared outcome. Paradoxically, safety will be (mis)attributed to this behaviour. Therefore, they are considered a barrier for genuine fear extinction during exposure in vivo, since harm beliefs are not disconfirmed[1]. Furthermore, safety behaviours may load spinal structures in a suboptimal manner, so these structures become sensitised and a source of ongoing peripheral nociceptive input.
Adaptive avoidance behaviour	The temporary avoidance of certain activities can be indicated in the presence of tissue damage (e.g., relative rest after an ankle sprain). When recovery of function and the participation in valued activities is prioritized (also see motivational account), a person will gradually explore whether it is possible to perform the painful movement or to load the painful tissue (e.g., gradually take support after an ankle sprain). When the load on the tissues is adequately increased based on the stages of tissue healing, this will improve recovery. A second reason why avoidance behaviour may be adaptive, is when a person lacks the physical capacity to safely perform certain activities. For example, it has been well-documented that the re-injury rates after an anterior cruciate ligament reconstruction dramatically increase when patients return to sport too early, without achieving certain physical criteria. In this case, avoiding full return to sport until the physical criteria are fulfilled seems adequate.
Overprotective avoidance behaviour	When avoidance behaviour is excessive relative to the context (overprotective avoidance behaviour), it becomes unhelpful. This is the case when avoidance behaviour persists after tissues have healed and do not need to be protected anymore. Another example is when avoidance behaviour spreads to safe activities in case of (acute) tissue damage (e.g., avoidance of walking in case of (acute) flexion-related low back pain). This latter is also an example of overgeneralisation.
(Over)generalisation	Generalisation is the spreading of fear of movement and avoidance behaviour to movements, situations or activities which are conceptually or perceptually similar to original harm-signalling stimuli. Overgeneralisation refers to generalisation to safe activities which should not be avoided or protected from a tissue healing point of view. For example, in case of an acute injury, the generalisation of avoidance behaviour towards movements that are best avoided from a tissue healing perspective is highly adaptive. It becomes unhelpful when there is overgeneralisation, indicating that safe activities or movements are avoided as well. In this context, category-based or conceptual overgeneralisation refers to fear and avoidance of safe movements or activities which are physically dissimilar but semantically related to the initial threat-inducing movements/activities. For example, when one gets injured due to tackle of an opponent, every uncontrollable, unexpected situation might elicit fear and avoidance behaviour. Learned fear can also overgeneralise to safe events due their perceptual (physical or proprioceptive) similarity with threat-relevant stimuli. For example, when lifting with a bent back in a person with chronic nonspecific low back pain is already associated with fear and is avoided, every flexion-related movement can elicit fear.
CONSIDERING BEHAVIOURAL ADAPTATIONS IN A MOTIVATIONAL PERSPECTIVE[2, 5, 6]	

	Pain-related fear of movement and behavioural adaptations never occur in isolation of context and ongoing goal pursuit. The transition from acute to chronic pain is not only explained by fear- or pain-induced avoidance behaviour, but also by task or *goal persistence* in the presence of pain and fear.
Goal persistence	A person may prioritize either a pain-related goal (e.g., avoidance of pain) or a non-pain-related goal (e.g., participation in valued life goals, despite the pain). When a person persists in performing activities despite pain or fear, this is referred to as goal persistence.
	In the context of goal persistence, subtle behavioural adaptations might be used to cope with the fear or pain, and can therefore be considered functional as they help to maintain goal pursuit. For example, one's goal might be to take care of the grandchildren, despite being in severe pain when lifting them with a bent back. Therefore, this person might decide to only pick the children up by bending the knees and a straight back. Of course, the presence of the behavioural adaptations may have negative consequences on the long term (see safety behaviours).
	Prioritization of either pain control/avoidance or persistence in activity participation depends on different factors. First, dispositional factors (e.g., individual personality traits, temperament, and genetics) influence personal behaviour and actions. For example, if someone feels responsible for a company or an organisation, or the household, this person might persist in these activities despite being in severe pain.
	Second, situational/contextual factors, such as the goal underlying an activity, are equally important. In different situations, different goals can be activated, and the perceived characteristics of these goals (e.g., importance/value, how congruent with one's values, feasibility, self-efficacy, required effort) will additionally determine the motivation to perform the activity. For example, a person might avoid bending activities with the back at work because bending is painful, but might endure in these activities to be able to take care of the children, or to engage in leisure activities.
Goal interferences	A person might dislike the fact that they avoid activities due to pain or fear, as it interferes with successful goal pursuit. This can result in negative affect. For example, a cyclist may stop cycling after a fall in a race, because the fear of falling is greater that the cyclist's wish to participate in races again. However, this can cause depressive symptoms in this person because this person identified as a cyclist.
Inter-goal relations	In context of inter-goal relations, inter-goal interference (i.e., pursuing one goal hinders attaining another goal – see goal interference) and inter-goal facilitation are described. This latter refers to the fact that pursuing one goal (e.g., cycling for good health) helps attaining another goal (e.g., spending time with friends).

1.   den Hollander M, Smeets R, van Meulenbroek T, van Laake-Geelen CCM, Baadjou VA, Timmers I. Exposure in Vivo as a Treatment Approach to Target Pain-Related Fear: Theory and New Insights From Research and Clinical Practice. *Phys Ther*. 2022;102:
2.   Hasenbring MI, Verbunt JA. Fear-avoidance and endurance-related responses to pain: new models of behavior and their consequences for clinical practice. *Clin J Pain*. 2010;26:747-753.
3.   Meulders A. Fear in the context of pain: Lessons learned from 100 years of fear conditioning research. *Behaviour Research and Therapy*. 2020;131:103635.

4.   Meulders A. From fear of movement-related pain and avoidance to chronic pain disability: a state-of-the-art review. *Current Opinion in Behavioral Sciences*. 2019;26:130-136.
5.   Van Damme S, Kindermans H. A self-regulation perspective on avoidance and persistence behavior in chronic pain: new theories, new challenges? *Clin J Pain*. 2015;31:115-122.
6.   Van Damme S, Van Ryckeghem DML, Wyffels F, Van Hulle L, Crombez G. No pain no gain? Pursuing a competing goal inhibits avoidance behavior. *PAIN®*. 2012;153:800-804.