Received: 18 May 2022 | Accepted: 19 May 2022

DOI: 10.1002/msc.1661

RESEARCH ARTICLE

WILEY

Reductions in movement-associated fear are dependent upon graded exposure in chronic low back pain: An exploratory analysis of a modified 3-item fear hierarchy

Mitchell T. Gibbs[1,2] | Natalie M. V. Morrison[3] | Matthew D. Jones[1,4] | Danielle Burgess[5] | Paul W. Marshall[2,6]

[1]School of Health Sciences, University of New South Wales, Sydney, New South Wales, Australia

[2]School of Health Science, Western Sydney University, Penrith, New South Wales, Australia

[3]School of Medicine, Western Sydney University, Sydney, New South Wales, Australia

[4]Centre for Pain Impact, Neuroscience Research Australia, Adelaide, Queensland, Australia

[5]Department of Health Science, Torrens University Australia, Adelaide, Queensland, Australia

[6]Department of Exercise Science, University of Auckland, Auckland, New Zealand

Correspondence

Mitchell T. Gibbs, School of Health Sciences, University of New South Wales, Room 202, Wallace Wurth Building, Kensington Campus, Sydney, NSW, 2052, Australia.
Email: Mitchell.gibbs@unsw.edu.au

Funding information

University of New South Wales, Grant/Award Number: CAUL 2022
Open access publishing facilitated by University of New South Wales, as part of the Wiley - University of New South Wales agreement via the Council of Australian University Librarians.

Abstract

Objective: To explore the effectiveness of a modified fear hierarchy on measuring improvements in movement-associated fear in chronic low back pain.

Methods: A modified 3-item fear hierarchy was created and implemented based on principles of graded exposure. This study was an exploratory analysis of the modified 3-item fear hierarchy from a larger clinical trial data set. Both groups received pain education and exercise, either bodyweight or strength training. Both groups performed item one on the hierarchy, the squat. Only the strength training group performed item 2, the deadlift. Neither group performed item 3, the overhead press. Analysis of Covariance and stepwise linear regression were used to explore results.

Results: Improvement in movement-associated fear was conditional upon graded exposure. Both groups improved in the squat movement ($p \leq 0.05$), which both performed. Only the strength training group improved in the deadlift ($p \leq 0.01$), and neither improved in the overhead press ($p \geq 0.05$).

Conclusion: Reductions in movement-associated fear are conditional upon graded exposure, based on the use of a novel modified 3-item fear hierarchy. Further research is needed to understand the utility of this tool in a patient-led approach to co-designing a graded exposure-based intervention.

KEYWORDS

chronic low back pain, fear hierarchy, graded exposure

1 | INTRODUCTION

Combined interventions containing exercise and pain education for chronic low back pain (CLBP) appear to produce moderate effects on pain and disability, and the combination of these elements looks to increase outcomes beyond either intervention alone (Siddall et al., 2021). The addition of pain education to exercise appears to better address psychosocial factors associated with pain and disability, such as pain catastrophizing and fear avoidance beliefs (Siddall et al., 2021). Indeed, it has been suggested the primary focus of pain education in combined interventions should be to facilitate engagement in movement through reducing movement-associated fear (Louw et al., 2020). Interestingly, the additive benefit of pairing exercise with education appears to simply occur from the combination of these two elements, with no requirement to use a particular exercise mode (Gibbs et al., 2022). This relationship is curious based on thoughts around education being beneficial to address exercise engagement through reduced fear of movement (Louw et al., 2020; Siddall et al., 2021), which implies the active component of the intervention contains movement(s) that are feared by the individual or involving elements of graded exposure (López-de-Uralde-Villanueva et al., 2016). However, the proposed causal role of movement-associated fear in combined interventions has not been explored. Therefore, it is unknown if pain education ubiquitously addresses movement associated fear in these interventions, or if an element of graded exposure is needed as well, such as specific movement to address an individual's specific fear.

Fear avoidance has been identified as a mediating variable in the relationship between pain and disability following exercise interventions, which should be addressed in clinical interventions (Marshall et al., 2017). As such, reductions in fear avoidance have become a priori goal for practitioners working with CLBP as a pragmatic means to improve engagement with physical activity and clinical outcomes. A common measurement of fear in clinical practice and research, the Fear Avoidance Beliefs Questionnaire (FABQ) (Waddell et al., 1993), examines an individual's concerns to overall physical activity (e.g. physical activity might harm my back). However, this tool, along with others such as the Tampa Scale for Kinesiophobia (Vlaeyen & Crombez, 1999), does not directly measure an individual's movement associated fear, but rather general concerns towards physical activity/movement. As such, these tools may 'miss' CLBP patients with highly specific movement-based fears, such as an athlete fearful of a particular movement/exercise, but with no concurrent concerns regarding general physical activity/exercise. In-turn, these tools do not allow for direct measurement of changes in patients movement associated fears following exercise and/or educational interventions.

One tool that does measure CLBP patient's movement associated fear is the Photograph Series of Daily Activities (PHODA) (Leeuw et al., 2007). The PHODA is a series of 100 (or 40 in the case of the short version (Leeuw et al., 2007) photographs of activities of daily living (ADLs), where a CLBP patient rates their perceived fear related to the image-represented movement. The PHODA appears a robust tool to measure movement-associated fear in CLBP patients, though, several limitations for use in clinical practice exist. The PHODA is not positioned to measure the direct effect of an intervention on movement-associated fear, unless certain conditions are met based on principles of graded exposure (López-de-Uralde-Villanueva et al., 2016); the inclusion of movements from the PHODA into the programme, and the patient having a specific fear(s) of the movement(s). The PHODA is not an individualised tool, meaning this tool may not capture CLBP patients (such as athletic populations) with specific movement fears, but no inability/apprehension to perform the included ADLs. Further, a key concern in using the PHODA clinically is the time to administer such a test of 40-100 photographs. Recent research has shown earlier engagement in movement may lead to improved self-efficacy compared to a longer duration clinical assessment (Gibbs & Marshall, 2018). Thus, a time-effective measurement tool, which allows individualised measurement of movement-based fear appears necessary for clinical exercise practice with CLBP patients.

Based on these current gaps in the literature, this research was developed as a feasibility study to investigate a modified 3-item fear hierarchy on measuring changes in movement associated fear following an exercise and education intervention. The movements selected for the modified 3-item fear hierarchy were not individualised as this stage of investigation aimed to explore feasibility. The researchers selected 3-items for the modified fear hierarchy after consulting with CLBP patients to observe movements commonly associated with fear/apprehension. The 3-items on the modified fear hierarchy were also constructed to ensure alignment with the exercise interventions to test the hypothesis of graded exposure to a specific movement leading to reduced fear.

2 | METHODS

2.1 | Study design

These data were collected as part of a clinical trial utilising a single-blind randomised controlled trial (RCT) design (Gibbs et al., 2022). These data were used for an exploratory analysis to explore the use of a novel modified fear hierarchy between two groups receiving the same pain education with different exercise modes. Outcomes were assessed immediately post intervention (where intervention extended for 8-week (see Figure 1)). This was a multi-centre study conducted in Sydney, Australia.

2.2 | Participants and procedure

The data of 50 participants were analysed in this study out of the total 64 participants from the larger RCT (Gibbs et al., 2022). Data were only collected from the first 50 participants relating to this exploratory investigation of the modified fear hierarchy. Recruitment methods are consistent with those reported in the larger RCT (Gibbs et al., 2022). Inclusion criteria was consistent with the broader CLBP literature to ensure generalisability and translation to practice

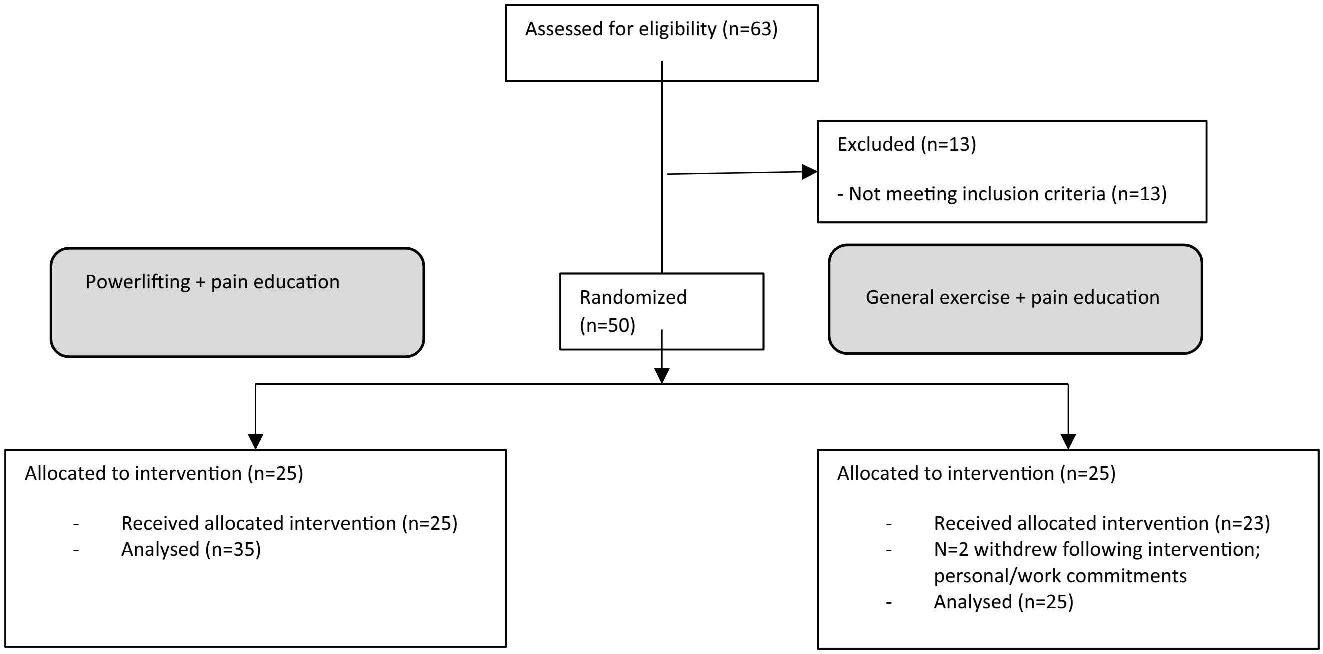


FIGURE 1 CONSORT diagram for randomised controlled trials

(Gibbs et al., 2022). Participants were screened for eligibility prior to enrolment in the study. Further, the Exercise and Sport Science Australia (ESSA) exercise pre-screening form was used prior to enrolment to ensure safety to exercise. Participants recorded as 'high risk' as per the ESSA and American College of Sport Medicine (ACSM) guidelines were not enroled into the study and were referred to the appropriate service with our best-practice advice on self-management of their CLBP.

Randomisation was undertaken by an individual independent of the study at Western Sydney University. Participants were entered into the randomisation after being screened for eligibility and randomisation was performed in blocks of 4 (e.g. out of 4 participants, 2 were allocated to General exercise Programme (GEP) and 2 to Strength training (ST) at random). Following group randomisation, the trainer of the corresponding group received an email with the participant's details for the purpose of scheduling.

2.3 | Interventions

Both interventions are reported as part of the larger RCT (Gibbs et al., 2022) and will be summarised here. Interventions were 8-week in duration for 1-h per week consisting of exercise and pain education. Both groups received the same pain education intervention, which was delivered in 15-min segments following exercise. The pain education was based on Butler and Moseley's "Explain Pain" (Butler & Moseley, 2013) and targeted components of task mastery derived from Bandura's self-efficacy theory (Bandura, 1977). The education was adapted in consultation with an experienced clinical health psychologist for delivery within the scope of practice of an exercise-based practitioner. The pain education curriculum is detailed in Appendix 1.

2.4 | Exercise interventions

To explore potential differences in movement-associated fear through the use of a novel 3-item fear hierarchy, the interventions used varying degrees of the included movements on the measurement tool. The movements on the novel 3-item fear hierarchy were the squat, deadlift, and overhead press. The ST group used both the squat and deadlift movement. The GEP group used the squat movement only. Neither group used the overhead press movement. This design allows for investigation of if a particular movement needs to be performed to observe changes in associated fear based on the novel 3-item fear hierarchy.

2.5 | Strength training

The strength training programme (Gibbs et al., 2022) was a gym-based programme exclusively utilising external loading. Exercises and the prescription of loading and volume is presented in Appendix 2. Weeks one to five were prescribed at higher volumes. The back squat, deadlift, and pin-Pendlay row exercises were prescribed on a progression system for the first 5-week. In Week 6, progression based on movement complexity/range of motion stopped and loading was the only variable increased. Week 6 asked the participant to work to a conservative 5-repetition maximum for the first three movements, and the participant was given a maximum of 3 sets to achieve the heaviest load they could lift for 5-repetitions. In week 7, the same protocol was applied for a conservative 3-repetition maximum and in week 8 for a conservative 1-rep maximum (1RM). A key feature of this group was the inclusion of both the squat and deadlift, which are two of the 3-items on the modified fear hierarchy tool.

2.6 | Traditional bodyweight exercise

The second group received a traditional callisthenic approach to CLBP, which has been reported to be as successful as an individualised programme in both clinical and behavioural outcomes (Gibbs & Marshall, 2018). The exercises and prescription of sets and repetitions is detailed in Appendix 3. The programme increased in complexity after 4-week to ensure both groups received progressive exercise, removing progression as a confounder of outcomes. As per the original protocol (Gibbs & Marshall, 2018), trainers were not able to modify the exercises in this programme. If a participant was unable to complete an exercise within this programme it was removed. A key element of this group was the inclusion of the squat movement but not the deadlift or overhead press, so participants in this group completed only one of the 3-items on the modified fear hierarchy.

2.7 | Clinical outcome measures

Visual analog scales (VAS) were used to measure current pain intensity, pain intensity in the last week, and pain intensity in the last month (Carlsson, 1983). A VAS is a 10 cm line with no pain on the left-hand side and worst pain on the right-hand side, with patients asked to mark the line for the corresponding pain intensity. Pain intensity was measured by the distance in cm from the start of the line (no pain), thus higher scores represent higher pain. Disability was measured with the Oswestry Disability Index (ODI) (Fairbank et al., 1980), which is a 10-item questionnaire assessing how CLBP affects the patient's day-to-day life in activities such as sitting, standing, walking, and lifting. The ODI is recorded between 0% and 100% with higher scores indicating increased levels of pain-related disability.

2.8 | Behavioural outcome measures

Additional to clinical outcome measures, behavioural measures were collected to observe the relationship between pain and disability with psychosocial factors including; Functional self-efficacy, fear avoidance beliefs, pain catastrophizing, anxiety and depression. Functional self-efficacy was measured using the functional subscale of the chronic pain self-efficacy questionnaire (Anderson et al., 1995), which is an 72-point scale with higher scores representing increased self-efficacy. The physical activity subsection of the fear avoidance beliefs questionnaire (FABQ) (Waddell et al., 1993) was used, which is a 4-item scale with scores ranging from 0 to 24. Higher scores represent increased fear of physical activity, and is proposed by the fear avoidance model to lead to increased disability (Waddell et al., 1993). The pain catastrophizing scale (PCS) (Sullivan et al., 1995) was used, and is a 13-item questionnaire with total scores ranging from 0 to 52, with high scores indicating increased catastrophizing about pain. The Hospital anxiety and depression scale (HADS) was used (Zigmond & Snaith, 1983). The HADS has 7-items each for both anxiety and depression, which are all measured from 0 to 3 with a total subscale score of 21. Scales are measured and reported separately to provide patient data for both anxiety and depression.

The modified 3-item fear hierarchy was also used at baseline and 8-week. This tool contained 3 movements with two images each, representative of the 'up' and 'down' phase of the movements. The movements were a squat, deadlift, and overhead press (Appendix 4). Participants were asked to score each movement out of 10 to demonstrate the amount of fear towards the movement (0 being no fear, and 10 being highly fearful). At baseline, this measure was collected prior to participants knowing the intervention they would receive as to not confound measurement.

2.9 | Statistical analysis

All data from the 50 participants included in this study were analysed using SPSS version 25 (IBM, New York, NY), using 'intention-to-treat' principles (i.e., all available data collected from randomised participants were analysed with the participants allocated group). Missing values were replaced by carrying the last available value forward (Overall et al., 2009) (Figure 1). To examine between-group differences, an analysis of covariance (ANCOVA) was performed. The ANCOVA was performed on the change variable (post score minus baseline), with the baseline scores treated as covariates. Effect sizes were the analysed for between group differences ($\eta 2 = 0.01$–0.058 small effect, 0.059–0.137 moderate effect, >0.138 large effect) (Cohen, 1992). Clinically meaningful indicators (CMI) were calculated for clinical outcomes, pain and disability, at the individual level. CMI were a 30% or more reduction on the ODI and VAS (Ostelo et al., 2008). Two stepwise regression analyses were used to observe what changes in behavioural variables explained changes in clinical outcomes. Of the two regressions, one had the change in disability as the dependent variable and the other had the change in current pain. Both analyses had all changes in behavioural outcomes including the modified 3-item fear hierarchy to observe changes owing to the intervention period. Statistical significance was set to $p < 0.05$.

3 | RESULTS

The data presented in this study were analysed as part of a larger registered clinical trial, meaning it is not possible to comment on specific recruitment rates. Out of the 50-participants data utilised for this study, one participant withdrew from the intervention owing to work commitments. No adverse events to either intervention were reported.

3.1 | Clinical outcomes

After 8-week both groups improved significantly from baseline in terms of pain and disability (Table 1). No significant between-group differences were reported for pain or disability with similar reporting of CMI in both groups. At 8-week, 68% of ST and GEP had

TABLE 1 Demographics, baseline/post intervention scores, and between-group differences

		Baseline		8-week			
	Group	Mean	SD	Mean	SD	Sig.	Partial Eta^2
Age	GEP	34.3	13.8				
	ST	35.3	12.5				
Gender (% female)	GEP	44%					
	ST	32%					
Squat	GEP	3.0	3.1	1.6*	2.3		
	ST	4.7	3.5	1.3**	1.6	0.188	0.046[a]
Deadlift	GEP	3.8	2.8	2.6	3.2		
	ST	3.6	3.0	1.4**	1.8	0.006	0.189[c]
OHP	GEP	2.4	2.7	1.8	2.6		
	ST	0.9	1.3	0.9	1.3	0.081	0.080[b]
ODI	GEP	14.8	8.5	8.1**	9.4		
	ST	19.6	8.3	11.9**	9.6	0.561	0.009[a]
VASc	GEP	3.3	2.3	1.4**	1.3		
	ST	3.3	1.9	1.5**	1.5	0.601	0.007[a]
VASw	GEP	5.7	1.9	3.3*	2.1		
	ST	5.5	2.0	3.8	2.7	0.670	0.005[a]
FAB	GEP	10.7	5.3	6.6**	4.5		
	ST	10.3	4.6	5.2**	4.2	0.673	0.005[a]
PCS	GEP	16.8	11.9	6.2**	7.2		
	ST	15.4	10.4	7.9**	8.9	0.630	0.006[a]
HADSa	GEP	6.5	4.0	4.7	4.8		
	ST	6.8	4.4	4.9	4.1	0.992	0.000
HADSd	GEP	3.9	3.0	3.0	3.0		
	ST	3.4	2.3	2.8	4.0	0.926	0.000
FSE	GEP	65.7	7.6	69.2*	4.3		
	ST	65.6	5.0	68.8*	4.9	0.597	0.008[a]

Abbreviations: FAB, Fear avoidance beliefs; FSE, Functional self-efficacy; HADSa, Anxiety; HADSd, Depression; ODI, Oswestry Disability Index; OHP, Overhead Press; PCS, Pain catastrophizing scale; VASc, Current pain; VASw, worst pain in the last week.

* = $p < 0.05$ ** = ≤ 0.001.

[a]Small effect size.

[b]moderate effect size.

[c]large effect size.

achieved CMI of disability. Further, 64% of ST and 68% of GEP had achieved CMI in current pain.

3.2 | Behavioural outcomes

Following the intervention, both groups reported significant differences in all behavioural outcomes other than depression and axiety (Table 1). No between-group differences were reported for any behavioural outcomes.

3.3 | Modified 3-item fear hierarchy

Following the intervention, both groups reported significant improvements (Table 1) in perceived fear of the squat movement. Only the ST group reported significant improvement in fear of the deadlift movement and neither group reported significant improvement for the overhead press. A large effect for between-group difference was observed for the deadlift movement favouring the ST group (Table 1), which was the only group to perform this movement. No between-group differences were found for the squat, which both groups performed, or overhead press, which neither group performed.

3.4 | Stepwise regression analysis

A portion of the improvements in pain and disability following the intervention were significantly explained by the post-intervention changes in functional self-efficacy and the squat item on the fear hierarchy, respectively. Changes in functional self-efficacy explained 38% of the variance in improvements in current pain following the intervention. Change in the squat movement, which both groups performed, was the only variable to explain a portion (12%) of the variance in improvements in disability. No other variables emerged significant within the regression analysis.

4 | DISCUSSION

The results of this study suggest CLBP interventions containing exercise and pain education have similar effects on pain and disability regardless of exercise mode. Interestingly, the results of this study suggest changes in movement-associated fear, as measured by a modified 3-item fear hierarchy, is conditional upon engagement with the specific movement. Both groups were prescribed the squat exercise, and subsequently saw significant improvement in associated fear from baseline with no between-group difference. Only the ST group was prescribed the deadlift exercise and a significant difference in associated fear was only observed for this group from baseline. Finally, no significant differences were observed for the overhead press, which was not performed by either group. Indeed, the lack of significant change in either group on the overhead press item (that neither group performed) can be viewed as test-re-test reliability as a change would not be expected on a movement not performed. Therefore, based on the exploratory results of this study, the relationship of improvements in movement-associated fear as measured by a modified fear hierarchy appear conditional upon engagement with the specific activity.

Stepwise regression analysis showed decreases in fear associated with the squat movement to explain a significant portion of the variance in improved disability. Indeed, this is the first utilisation of this measurement tool, so these results need to be treated with caution and further investigated. Further research is needed to understand how improvements in movement associated fear as measured by the modified fear hierarchy may mediate improvements in clinical outcomes.

The modified fear hierarchy tool was created as a means to pragmatically measure movement-associated fear in exercise-based management of CLBP. Further, this tool has the ability to double as a consultation process whereby the individual is given agency by the practitioner to discuss what movements they perceive as fearful and meaningful. Thus, based on the principle of a fear hierarchy being exposure based, individual items may be irrelevant as the concept of a modified fear hierarchy within exercise practice would be dynamic. Theoretically, the implementation of a modified fear hierarchy, such as that used in this study, would be better suited as a template with individualised movements based on patient goals/fears, in similar principle to the patient specific functional scale (Stratford et al., 1995). Indeed, this utilisation of a modified fear hierarchy for exercise practice is consistent with literature demonstrating the efficacy of graded exposure for reductions in fear, pain, and disability in CLBP (Leonhardt et al., 2017; López-de-Uralde-Villanueva et al., 2016; Macedo et al., 2010; Macedo et al., 2012; J. W.; Vlaeyen et al., 2001). Therefore, this study should be viewed as a general, controlled, example of how a modified fear hierarchy could be implemented in practice. However, this tool needs to be better explored before clinical application through exploration of a patient-led approach and/or a patient-practitioner collaborative approach.

A key limitation of this paper is the non-inclusion of a measurement tool such as the PHODA (8) to directly compare the modified 3-item fear hierarchy. This study was performed as a feasibility investigation to observe the usefulness of the modified 3-item fear hierarchy and inform future research and practical considerations. Moreover, this study was conducted in a controlled manner where the three- movements on the modified fear hierarchy were determined by the researchers, rather than a patient-led approach consistent with fear hierarchy practice in psychology-based disciplines (Bailey et al., 2010; Schemer et al., 2018). Further research should investigate the efficacy of a collaborative approach with the patient whereby the individual is given agency to discuss their specific movement associated fears to be input to the modified fear hierarchy in an exercise setting. Indeed, this collaborative approach may be subsequently used as a tool to guide/inform the intervention per principles of graded exposure, modelled off the use of fear hierarchies in psychological practice.

5 | CONCLUSION

This study was an exploratory analysis of a randomised controlled trial to investigate the clinical utility of a modified 3-item fear hierarchy. Therefore, based on the nature of this research, these results should be interpreted as hypothesis generating, rather than clinically applicable. However, based on the existing literature, it appears these results support the notion that graded exposure principles are efficacious in reducing movement-associated fear in CLBP, which may benefit from the implementation of a modified fear hierarchy.

AUTHOR CONTRIBUTIONS

Mitchell T. Gibbs: Study design, acquisition of data, analysis and interpretation of data, draft final article, final approval of article. Natalie M. V. Morrison: Study design, draft final article, final approval of article. Matthew D. Jones: Draft final article, final approval of article. Danielle Burgess: Draft final article, final approval of article. Paul W. Marshall: Study design, analysis and interpretation of data, draft final article, final approval of article.

ACKNOWLEDGEMENTS

The authors would like to thank Adrian Caldarola, Isaac Harrison, Stephanie Croucher, Jayden Caccamo, Catherine Phillips, and Andrew Lovell for their assistance and support through the clinical trial process. MG was supported by the Australian government Research Training Programme. No other funding was received for this project.

Open access publishing facilitated by University of New South Wales, as part of the Wiley - University of New South Wales agreement via the Council of Australian University Librarians.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

Ethics approval was received from the "Western Sydney University" Human Research Ethics Council, Approval number H13020. This trial was registered with the Australia and New Zealand Clinical Trials Register, trial id, ACTRN12618002001279.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Mitchell T. Gibbs https://orcid.org/0000-0002-8053-308X

REFERENCES

Anderson, K. O., Dowds, B. N., Pelletz, R. E., Edwards, W. T., & Peeters-Asdourian, C. (1995). Development and initial validation of a scale to measure self-efficacy beliefs in patients with chronic pain. *Pain*, *63*(1), 77–83.

Bailey, K. M., Carleton, R. N., Vlaeyen, J. W., & Asmundson, G. J. J. C. b. t. (2010). Treatments addressing pain-related fear and anxiety in patients with chronic musculoskeletal pain: A preliminary review. *Cognitive Behaviour Therapy*, *39*(1), 46–63.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191.

Butler, D. S., & Moseley, G. L. (2013). *Explain pain* (2nd ed.). Noigroup Publications.

Carlsson, A. M. (1983). Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. *Pain*, *16*(1), 87–101.

Cohen, J. J. C. d. i. p. s. (1992). Statistical power analysis. *Statistical power analysis*, *1*(3), 98–101.

Fairbank, J. C., Couper, J., Davies, J. B., & O'brien, J. P. (1980). The oswestry low back pain disability questionnaire. *Physiotherapy*, *66*(8), 271–273.

Gibbs, M. T., & Marshall, P. W. M. (2018). Buy-in for back pain: Does individualization matter? *Journal of Clinical Exercise Physiology*, *7*(4), 82–93. https://doi.org/10.31189/2165-6193-7.4.82

Gibbs, M. T., Morrison, N. M., Raftry, S., Jones, M. D., & Marshall, P. W. (2022). Does a powerlifting inspired exercise programme better compliment pain education compared to bodyweight exercise for people with chronic low back pain? A multicentre, single-blind, randomised controlled trial. *Clinical Rehabilitation*, 269215522 1095484. https://doi.org/10.1177/02692155221095484

Leeuw, M., Goossens, M. E., van Breukelen, G. J., Boersma, K., & Vlaeyen, J. W. S. (2007). Measuring perceived harmfulness of physical activities in patients with chronic low back pain. *The Photograph Series of Daily Activities—Short Electronic Version*, *8*(11), 840–849.

Leonhardt, C., Kuss, K., Becker, A., Basler, H.-D., deJong, J., Flatau, B., Laekeman, M., Mattenklodt, P., Schuler, M., Vlaeyen, J., & Quint, S. (2017). *Graded exposure for chronic low back pain in older adults: A pilot study*. *40*(1), 51-59.

López-de-Uralde-Villanueva, I., Munoz-Garcia, D., Gil-Martinez, A., Pardo-Montero, J., Munoz-Plata, R., Angulo-Diaz-Parreno, S., & La Touche, R. J. P. M. (2016). *A systematic review and meta-analysis on the effectiveness of graded activity and graded exposure for chronic nonspecific low back pain*. *17*(1), 172–188.

Louw, A., Sluka, K. A., Nijs, J., Courtney, C. A., Zimney, K. J. J., & Therapy, S. P. (2020). *Revisiting the provision of Pain Neuroscience Education: An adjunct intervention for patients, but a primary focus for clinician education*. 0 1–12.

Macedo, L. G., Latimer, J., Maher, C. G., Hodges, P. W., McAuley, J. H., Nicholas, M. K., Tonkin, L., Stanton, C. J., Stanton, T. R., & Stafford, R. (2012). Effect of motor control exercises versus graded activity in patients with chronic nonspecific low back pain: A randomized controlled trial. *Physical Therapy*, *92*(3), 363–377.

Macedo, L. G., Smeets, R. J., Maher, C. G., Latimer, J., & McAuley, J. H. J. P. t. (2010). *Graded activity and graded exposure for persistent nonspecific low back pain: A systematic review*. *90*(6), 860–879.

Marshall, P. W., Schabrun, S., & Knox, M. F. (2017). Physical activity and the mediating effect of fear, depression, anxiety, and catastrophizing on pain related disability in people with chronic low back pain. *PLoS One*, *12*(7), e0180788.

Ostelo, R. W., Deyo, R. A., Stratford, P., Waddell, G., Croft, P., Von Korff, M., Bouter, L. M., & Henrica, C. J. S. (2008). *Interpreting change scores for pain and functional status in low back pain: Towards international consensus regarding minimal important change*. *33*(1), 90–94.

Overall, J. E., Tonidandel, S., & Starbuck, R. R. J. S. S. R. (2009). *Last-observation-carried-forward (LOCF) and tests for difference in mean rates of change in controlled repeated measurements designs with dropouts*. *38*(2), 492–503.

Schemer, L., Vlaeyen, J. W., Doerr, J. M., Skoluda, N., Nater, U. M., Rief, W., & Therapy. (2018). Treatment processes during exposure and cognitive-behavioral therapy for chronic back pain. A single-case experimental design with multiple baselines. *Behaviour Research and Therapy*, *108*, 58–67.

Siddall, B., Ram, A., Jones, M. D., Booth, J., Perriman, D., & Summers, S. J. J. P. (2021). The short-term impact of combining pain neuroscience education with exercise for chronic musculoskeletal pain: A systematic review and meta-analysis. *Pain*, *163*(1), e20-e30.

Stratford, P., Gill, C., Westaway, M., & Binkley, J. (1995). Assessing disability and change on individual patients: A report of a patient specific measure. *Physiotherapy Canada*, *47*(4), 258–263.

Sullivan, M. J. L., Bishop, S. R., & Pivik, J. (1995). The pain catastrophizing scale: Development and validation. *Psychological Assessment*, *7*(4), 524.

Vlaeyen, J. W. S., & Crombez, G. (1999). Fear of movement/(re) injury, avoidance and pain disability in chronic low back pain patients. *Manual Therapy*, *4*(4), 187–195.

Vlaeyen, J. W., deJong, J., Geilen, M., Heuts, P. H., & van Breukelen, G. (2001). Graded exposure in vivo in the treatment of pain-related fear: A replicated single-case experimental design in four patients with chronic low back pain. *Behaviour Research and Therapy*, *39*(2), 151–166.

Waddell, G., Newton, M., Henderson, I., Somerville, D., & Main, C. J. (1993). A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. *Pain*, *52*(2), 157–168.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, *67*(6), 361–370.

How to cite this article: Gibbs, M. T., Morrison, N. M. V., Jones, M. D., Burgess, D., & Marshall, P. W. (2023). Reductions in movement-associated fear are dependent upon graded exposure in chronic low back pain: An exploratory analysis of a modified 3-item fear hierarchy. *Musculoskeletal Care*, *21*(1), 25–34. https://doi.org/10.1002/msc.1661

APPENDIX 1

Pain education layout

Week	Topic	
1	Overview of basic pain neuroscience	showing participants Professor Lorimer Moseley's TEDx talk video (https://youtu.be/gwd-wLdIHjs). Participant is then filmed performing 3-squat and 3-bend based movements. No coaching is given to these movements.
2	Pain neuroscience as it relates to everyday life	Review the basic principles of pain neuroscience and create parallels through examples in everyday life. Analogies were developed to describe pain, the brain, the nervous system, and concepts such as hypervigilance. This week ends with providing the participant with a basic reflection question, 'what is the message behind this pain/why is protection needed?', as the individual has now learnt pain is a protective mechanism.
3	The role of beliefs and emotion in pain	Introduce the roll of beliefs, preconception, meaning, emotion, and stress on the modulation of pain.
4	Hurt doesn't equal harm, what is damage?	Session ends with two additional reflection questions to use in the instance of pain increase, 'would someone without a history of back pain have the same response to this task?' and 'is this really enough to cause damage?'. These questions provide a platform for the participant to contextualise their pain in the scope of if it is a normal response to something they are doing (e.g. normal delayed onset muscle soreness), and/or if this is enough to cause damage based on their new understanding of both what damage is and how resilient and robust they are.
5	The role of exercise in pain	what damage is and how resilient and robust they are. Week 5 – The role of exercise providing positive context to the above reflection question and being a physical process of exposure to feared or worrisome movements. Exercise can provide a positive context to the reflection questions. For example, if a person is able to lift a certain load above the activity of daily living that may cause a painful increase, the final reflection question of 'is this enough to cause damage?'. Additionally, we provide general advice around exercise, which is as follows: gradually work towards something you
		may worry about, rather that ruling it out, and, make sure it something you enjoy.
6	Task mastery week	The participant is filmed performing the same 3-squats and 3-bends as week 1 with no coaching. Both videos (week 1 and 6) are played to the participant, allowing them to comment on their perception of the movements in the videos and changes from week 1. This component is to instil a sense of task mastery to influence self-efficacy (Bandura, 1986).
7	Creating a pain tool-box	The participant is asked to create a 'pain toolbox' for self-management in the case of a flare up. This is self-directed and is written by the participant as a series of tools they have at their disposal to use in case of a flare-up
8	Reflection and wrap up	Finally, the participant is provided a summary of the pain education and an action plan containing the reflection questions and tips around exercise for pain management.

APPENDIX 2

Powerlifting training model

Week	Exercise	Sets	Reps	Load	Rest
1-5	Back squat*	3	5-8	2RIR	1.5-2.5min
	Bench press	3	5-8	2RIR	1.5-2.5min
	Deadlift*	3	5-8	2RIR	1.5-2.5min
	Leg press	3	10	2RIR	1-2min
	Pin-Pendlay row*	3	10	2RIR	1-2min
	Lat Pull down	3	10	2RIR	1-2min
6	Back squat*	1-3	5	1RIR	1.5-2.5min
	Bench press	1-3	5	1RIR	1.5-2.5min
	Deadlift*	1-3	5	1RIR	1.5-2.5min
	Leg press	3	10	2RIR	1-2min
	Pin-Pendlay row*	3	10	2RIR	1-2min
	Lat Pull down	3	10	2RIR	1-2min
7	Back squat*	1-3	3	1RIR	1.5-2.5min
	Bench press	1-3	3	1RIR	1.5-2.5min
	Deadlift*	1-3	3	1RIR	1.5-2.5min
	Leg press	3	10	2RIR	1-2min
	Pin-Pendlay row*	3	10	2RIR	1-2min
	Lat Pull down	3	10	2RIR	1-2min
8	Back squat*	1-3	1	1RIR	1.5-2.5min
	Bench press	1-3	1	1RIR	1.5-2.5min
	Deadlift*	1-3	1	1RIR	1.5-2.5min
	Leg press	3	10	2RIR	1-2min
	Pin-Pendlay row*	3	10	2RIR	1-2min
	Lat Pull down	3	10	2RIR	1-2min

APPENDIX 3

General exercise programme

Week	Exercise	Sets	Reps	Cadence	Rest
1-4	Quadruped	3	6	1/10/1	1-2min
	Curl up	3	6	1/10/1	1-2min
	Split squat	3	20	1/3/1	1-2min
	Push up	3	20	1/3/1	1-2min
	Supine bridge	3	6	1/10/1	1-2min
	Overhead squat	3	20	1/3/1	1-2min
	Side-lying leg raise	3	20	1/3/1	1-2min
5-8	Full body Quadruped	3	6	1/10/1	1-2min
	Side bridge	3	6	1/10/1	1-2min
	Walking lunge	3	20	1/3/1	1-2min
	Alternate hand position Push up	3	20	1/3/1	1-2min
	Single leg Supine bridge	3	6	1/10/1	1-2min
	Sumo squat	3	20	1/3/1	1-2min
	Hip hinge	3	20	1/3/1	1-2min

APPENDIX 4

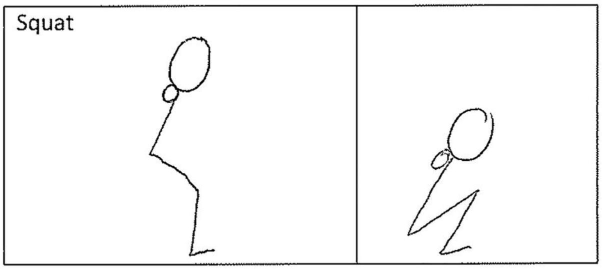
Fear scale

Fear Scale

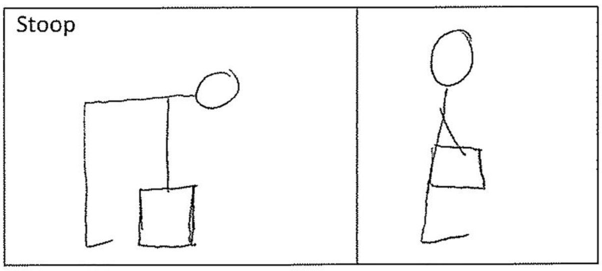
A number of movements that are common activities of daily living, and may be included in exercise programs are pictured below. Please rate in each of the blanks next to the movement, how fearful you are of these movements.

Rate your degree of fear with a number from 0 – 10 using the scale below.

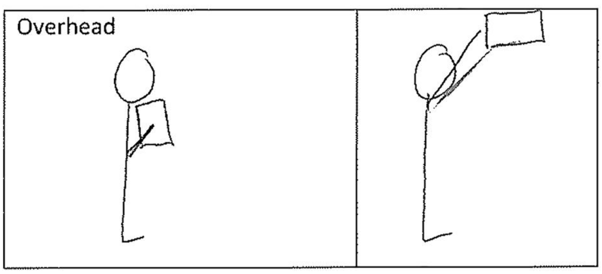
0	1	2	3	4	5	6	7	8	9	10
No Fear at all				Moderately fearful						Highly fearful


Squat

Fear 0-10


Stoop

Fear 0-10


Overhead

Fear 0-10