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Research

Keeping the abdomen relaxed versus contracted during Pilates improves disability slightly and may improve other outcomes in chronic non-specific low back pain: a randomised trial

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KEY WORDS

Pilates-based exercises
Chronic pain
Low back pain
Muscle contraction
Randomized controlled trial

ABSTRACT

Question: In patients with non-specific chronic low back pain, what is the effect of education to keep the abdomen relaxed versus contracted during Pilates exercises on pain intensity, disability, function and global perceived effect? **Design**: Two-group, parallel, randomised trial with concealed allocation and intention-to-treat-analysis. **Participants**: A total of 152 patients with non-specific chronic low back pain participated in the trial. **Intervention**: All participants were randomised to one of two groups and treated with Pilates exercises for 12 weeks (twice a week for 60 minutes). The control group (n = 76) received guidance on the specific activation of the core muscle group—primarily the abdominals, pelvic floor, diaphragm and deep spinal muscles—while the experimental group (n = 76) received guidance to perform the exercises in a relaxed and smooth way. **Outcome measures**: Primary outcomes were pain intensity and disability at 12 weeks. Secondary outcomes were patient-specific function and global improvement at 12 weeks. **Results**: Compared with keeping the abdomen contracted during Pilates, education to keep it relaxed led to these adjusted mean differences: change on the 0-to-10 pain scale (−0.6, 95% CI −1.4 to 0.2), change on the 0-to-24 disability scale (−1.4, 95% CI −2.6 to −0.2), change on the 0-to-10 patient-specific function scale (0.3, 95% CI −0.3 to 0.9) and final score on the −5 to +5 global perceived effect (0.6, 95% CI −0.1 to 1.2). **Conclusion**: Education to relax the abdominal muscles during Pilates exercises resulted in slightly greater improvement in disability compared with Pilates with education to keep the abdomen contracted. For the other outcomes (pain, patient-specific function and global perceived effect), the effect of keeping the abdomen relaxed during Pilates was unclear, with confidence intervals ranging from roughly as good to mildly better than keeping the abdomen contracted. **Registration**: NCT05336500. **[Lunkes LC, Dias Neto MA, Barra LF, de Castro LR, de Sá Ferreira A, Meziat-Filho N (2026) Keeping the abdomen relaxed versus contracted during Pilates improves disability slightly and may improve other outcomes in chronic non-specific low back pain: a randomised trial. *Journal of Physiotherapy* 72:116–121]**
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Introduction

Low back pain is one of the leading causes of disability worldwide. Beyond individual impact, it also leads to significant socioeconomic impact and burden on healthcare systems.[1,2] Low back pain is a common condition with often unidentified specific causes.[3] It affects function and quality of life, involving physical, psychological and social factors. Promoting an active lifestyle and minimising unnecessary treatments is essential.[4] Clinical guidelines recommend non-pharmacological interventions, including therapeutic exercises and pain management education, as the first line of treatment for chronic low back pain.[5–7] In a recent network meta-analysis, Pilates was as effective or more effective on pain and function than other exercise types in people with chronic low back pain.[8]

Pilates has been widely practised, promoting improved function and pain reduction by enhancing muscle strengthening, motor control and mobility.[9] Pilates involves six principles: breathing, centring, concentration, control, precision and flow.[10] The benefits in individuals with chronic low back pain are noticeable within 12 weeks. Sessions are typically recommended to last about 60 minutes, occurring two to three times per week, under the supervision of certified physiotherapists.[11,12] The exercises should incorporate isometric strengthening, global stretching, breathing techniques and spinal alignment to enhance body awareness.[13]

Traditionally, Pilates emphasises core muscle activation during exercise execution,[14,15] particularly engaging the transversus abdominis, lumbar multifidus and pelvic floor muscles to promote lumbar stabilisation.[16,17] However, there is ongoing debate regarding

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the need for this specific contraction to achieve therapeutic benefits.[6,18] Furthermore, in individuals with chronic low back pain, the transversus abdominis does not appear to show delayed activation.[19] Interestingly, symptomatic individuals exhibit increased activation of the erector spinae muscles during functional tasks, which challenges the rationale for further stimulating these muscles.[20] Recent evidence suggests that excessive rigidity may negatively impact movement and exercise adaptation, while muscle relaxation and movement fluidity may be equally effective strategies for rehabilitation.[21,22]

It is believed that no randomised clinical trials have compared advice to contract or relax core muscles during Pilates exercise for treating non-specific chronic low back pain.

Therefore, the research question for this randomised trial was:

In patients with non-specific chronic low back pain, what is the effect of education to keep the abdomen relaxed versus contracted during Pilates exercises on pain intensity, disability, function and global perceived effect?

Methods

Design

A two-group, parallel, randomised trial with concealed allocation and intention-to-treat-analysis was conducted. All patients signed the informed consent form prior to participation. The full protocol manuscript was prospectively registered and published elsewhere.[23,24] The trial was reported following the CONSORT statement[25] and the TIDieR checklist.[26]

This study was conducted at a physiotherapy school clinic in Lavras, Brazil. The date of the first enrolment was 03 June 2022 and the last participant's data were collected on 13 July 2023. Patients were recruited from the community by social media and referral of physicians. Eligible patients who agreed to participate in the study signed an informed consent form before enrolment. The recruitment started in May 2022 and continued at a rate of 14 participants per month on average.

A computer-generated allocation sequence was used to allocate participants to receive Pilates method exercises, with education to keep the abdomen either relaxed or contracted. A random sequence in blocks of four was generated through a computer program by a researcher not involved in data collection and concealed in 152 sequentially numbered, opaque and sealed envelopes, thus assuring concealed allocation of participants to the study groups. After the baseline data collection, a researcher opened the envelopes and referred the participant to the physiotherapist responsible for the respective group of allocation. The participant started treatment in the same week.

Due to the nature of the interventions, it was not possible to blind the participants and the treating clinicians. The assessors were not considered blinded because the outcomes were self-reported and participants were not blinded. However, to guarantee that the treatment expectation was evenly balanced between the groups and to decrease measurement bias, the participants did not know the study hypothesis, the researchers administering the self-reported outcome questionnaires did not know the participant's intervention group and the statistician was blinded to the group allocation.

Participants, therapists and centres

We included participants aged $\geq$ 18 years, with non-specific low back pain with symptoms for $\geq$ 12 weeks and who had not had an episode of worsening pain in the prior 6 weeks. Participants also had to be able to move independently (with or without assistance) and to understand Portuguese well enough to be able to fill in the questionnaires. A score $>$ 4 points on the Roland-Morris Disability Questionnaire (RMDQ) was also required for inclusion. People were excluded if: the main pain area was other than the lumbar spine (eg, nerve root compression or herniated disc with radicular pain, lateral or central stenosis); they had undergone surgery on the lumbar spine; they had undergone surgery on the lower limbs or abdominal region $<$ 6 months ago; or they had undergone an invasive procedure for pain relief (eg, epidural injection, rhizotomy) in the prior 3 months. People were also excluded if: they had a diagnosis of inflammatory rheumatologic diseases, progressive neurological disease or viral diseases as the primary cause of pain; they had an unstable heart condition; scoliosis was the primary cause of pain; or if malignancy, acute trauma (in the prior 6 months), infection or spinal cord/cauda equina compression were present.

A physiotherapist certified in the Pilates method with $>$ 10 years of clinical practice trained two other physiotherapists, both certified in the Pilates method (100 hours of training), in the exercise protocol. Participants were recruited from a physiotherapy teaching clinic affiliated with a Brazilian university, where supervised student-led physiotherapy services are provided to the community.

Interventions

Patients included in this trial were randomised to receive Pilates method exercises associated with education to keep the abdomen relaxed (experimental group) or contracted (control group). Based on a validated protocol for chronic low back pain,[27] nine Pilates exercises (a single series, with 10 repetitions) were performed in both groups: spine stretch, spine twist, hundreds, one leg circle, plank, leg pull front, swimming, rocking and swan. Additional equipment and materials were not used, with the intention that this protocol could be executed in any circumstances. The level of difficulty of the exercises was individually tailored for each participant, and the progression of the exercises depended on comfort and individual postural compensations. The sessions were prescribed to be performed for 60 minutes, twice a week for 12 weeks. The Pilates exercises performed by each group were the same. The instruction on how to perform the Pilates exercises (ie, core muscles contracted or relaxed) was administered to each participant individually by one of the certified physiotherapists.

In the control group, participants were instructed about the performance of exercises with activation of specific musculature: transversus abdominis, diaphragm, obliques, multifidus and pelvic floor. This characterised the contraction of the 'core' muscles (sometimes referred to as the 'centre of strength' or 'powerhouse' in the Pilates method), conceptualised by stabilisation depth and activation of abdominal bracing. During execution of the exercises, participants received stimuli through verbal commands, which were reinforced continuously so that the contraction of the muscles was performed throughout the protocol.

In the experimental group, participants were instructed to perform the exercises in a relaxed and smooth way, keeping only breathing and concentration during their execution. Also, at no time were the participants instructed to perform abdominal muscle contraction or activation of the core stabilisers.

Sessions were conducted in different environments and without any contact with therapists and participants between the two intervention groups. The assessment of treatment fidelity was performed by in vivo observations as well as video recording during the trial. Both groups were monitored, ensuring adequate adherence to the treatment that was performed as planned.

Outcome measures

Initially, participants were evaluated by a physiotherapist who was blinded to the allocation of intervention groups, confirming their eligibility according to the eligibility criteria. This screening involved taking a brief subjective history and the application of the RMDQ. Eligible participants were informed about the objectives and procedures of the study, without discussion of how the two interventions differed. They were informed that there were 'two active interventions' and that it was 'not yet known which one is superior'. Data collected in the baseline assessment included:

sociodemographic information (age and sex); symptom duration and number of pain areas; family history of low back pain; whether magnetic resonance imaging had been performed; chronicity risk, based on the Örebro Musculoskeletal Pain Questionnaire;[28] history of Pilates method practice; and stressful life events.

Primary and secondary outcomes

All scales and questionnaires used to evaluate the primary and secondary outcomes had been translated and adapted to Brazilian Portuguese and shown to have adequate measurement properties.[29–31] Participants completed these assessments at baseline and 12 weeks after randomisation. The primary outcomes were pain intensity and disability. Secondary outcomes were function and global improvement. The assessor did not treat any of the participants and was kept unaware of their group allocation. Assessors also did not have access to where the treatment was administered or the waiting room.

Primary outcomes were pain intensity and disability related to non-specific chronic low back pain. Pain intensity was measured by the Brazilian version of the 11-point numerical pain scale,[29,30] which varies between 0 and 10 points, where 0 is 'no pain' and 10 is 'the worst pain imaginable'. Participants reported pain intensity based on the prior 7 days. Disability was measured by the Brazilian version of the RMDQ.[31] The RMDQ contains 24 statements describing limitations in daily activities due to low back pain. Participants indicate which statements apply to them on the day of assessment. Each endorsed item scores 1 point (total score 0 to 24), with higher scores indicating greater disability.

Secondary outcomes were patient-specific function and perceived global improvement. Patient-specific function was measured by the Patient-Specific Functional Scale,[30] which consists of an interview in which the patient identifies three important activities that are limited or avoided because of low back pain. For each activity, the score ranges from 0 'unable to perform' to 10 'able to perform at the same level as before the problem'. The average of the scores of the three activities was calculated, with higher scores indicating a better functional ability. Global perceived effect was measured by the Global Perceived Effect Scale;[30] this 11-point scale ranges from –5 'much worse' to 0 'no change' and +5 'completely recovered'. To assess perceived global effect, participants were asked: 'Compared to the start of your first episode, how would you describe your low back pain in the past few days?'. Positive scores indicate recovery, while negative scores indicate worsening of symptoms.

Data analysis

The sample size required for this study was calculated based on each of the primary outcomes, with an alpha of 5%, power of 80% and a possible loss to follow-up of 15%. For disability, the other input data were a difference sought of 4.0 points and a standard deviation of 4.9, whilst for pain, the other input data were a difference sought of 1.0 and a standard deviation of 2.0.[32–34] The larger of these calculations indicated that 152 participants (76 per group) were needed.

The analysis of the data obtained during the research was carried out by a statistician who had access to the coded data. All analyses followed the intention-to-treat principle. Missing data were assumed to be missing completely at random. Multiple imputation was used to account for these missing data.[35] Missing values in outcome variables were estimated using multiple imputations by chained equations after 50 replicated imputed data sets. Variables included in the multiple imputation process included group, time and the respective outcome variable. Descriptive statistics summarised the characteristics of participants in the two treatment groups. The outcomes of pain intensity, disability, function and global effect were analysed using repeated-measures, linear mixed models (with participants and time as random factors) that included all the scores that were reported after randomisation with the baseline scores and treatment clusters as covariates. Adjusted mean differences were estimated at 12 weeks after randomisation. Multiple comparisons were performed using the Tukey test. Statistical analysis was performed using RCTapp Shiny app.[36] The results were interpreted according to 95% confidence intervals.

Results

Compliance with the study protocol

All of the prospectively registered primary and secondary outcomes were measured, analysed and reported. All participants received only the intervention to which they were originally randomly allocated. All participants completed the 12-week Pilates exercise program (24 sessions in total, consisting of two 60-minute sessions per week).

Flow of participants through the study

A total of 510 patients were assessed for eligibility between May 2022 and April 2023. At the initial assessment of eligibility, 358 patients were excluded because they did not meet the inclusion criteria, declined to participate or for other practical reasons. A total of 152 participants were eligible, consented to participate and underwent randomisation. Each of the two groups were randomly allocated 76 participants. Altogether, 94% (n = 143) of participants completed the 12-week assessment: 98% (n = 73) from the experimental group and 96% (n = 70) from control group (Figure 1).

The baseline characteristics of the participants are presented in Table 1 and in the first two columns of data in Table 2. The groups were similar at baseline. Most participants were women, mainly middle-aged, with a symptom duration of 95 months (SD 143), a family history of low back pain and no stressful life events. Most participants had not previously used Pilates. Both groups presented moderate levels of pain intensity and disability at baseline.

Effects of keeping the abdomen relaxed during Pilates

Primary outcomes

Although commonly used thresholds were nominated in the sample size calculation, keeping the abdomen relaxed incurs no extra cost, effort, time, risk or discomfort compared with keeping the abdomen contracted, so arguably any benefit of keeping the abdomen relaxed over keeping it contracted can be considered worthwhile. Keeping the abdomen contracted instead involves more effort and perhaps discomfort, so a larger benefit would be required to make it worthwhile compared with keeping the abdomen relaxed.

Pain: The mean change on the 0-to-10 pain scale due to keeping the abdomen relaxed instead of contracted was uncertain. Although the adjusted mean difference was –0.6, which favoured keeping the abdomen relaxed, the confidence interval ranged from a clear benefit from keeping it relaxed (–1.4) to a negligible difference (0.2) (Table 2). For individual participant data, see Table 3 on the eAddenda.

Disability: The mean change on the 0-to-24 disability scale favoured keeping the abdomen relaxed over keeping it contracted: adjusted MD –1.4 (95% CI –2.6 to –0.2) (Table 4). For individual participant data, see Table 3 on the eAddenda.

Secondary outcomes

Patient-specific function: The change on the 0-to-10 Patient-Specific Functional Scale due to keeping the abdomen relaxed instead of contracted was unclear. Although the adjusted mean difference was 0.3, which favoured keeping the abdomen relaxed, the confidence interval ranged from a negligible difference (–0.3) to a benefit from keeping the abdomen relaxed (0.9) (Table 2). The final score on the –5 to +5 global perceived effect scale was also unclear. Although the mean difference was 0.6, which favoured keeping the abdomen relaxed, the confidence interval ranged from a negligible difference (–0.1) to a clear benefit from keeping the abdomen relaxed (1.2) (Table 4). For individual participant data, see Table 3 on the eAddenda.

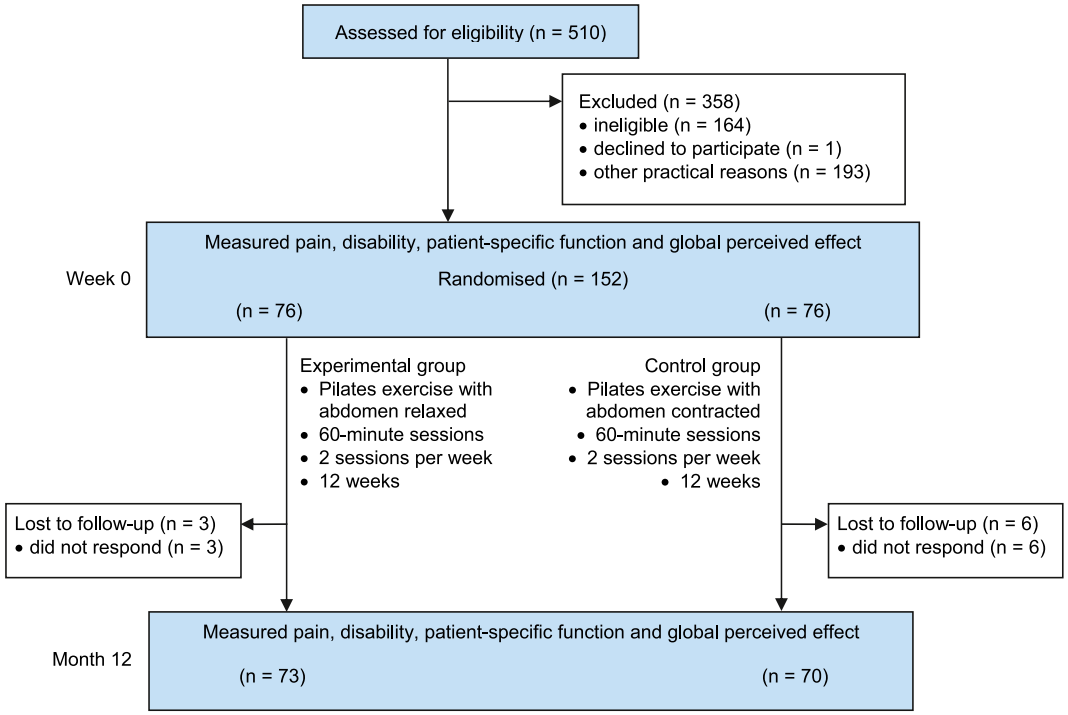


Figure 1. Flow of participants through the trial.
Note that the results tables show data on 152 participants at 12 weeks due to multiple imputation of missing data.

Table 1
Characteristic of participants at baseline.

Characteristic	Exp (n = 76)	Con (n = 76)
Age *(y)*, mean (SD)	40 (14)	42 (15)
Sex, n (%) female	59 (78)	62 (82)
Symptom duration *(mth)*, mean (SD)	95 (97)	94 (179)
Pain areas *(n)*, mean (SD)	7 (6)	7 (5)
Family history of low back pain, n (%)	54 (71)	51 (67)
MRI performed, n (%)	34 (45)	35 (46)
Chronicity risk[a], n (%)	57 (75)	58 (76)
Prior use of Pilates method, n (%)	25 (33)	24 (32)
Life stress events, n (%)	36 (47)	37 (49)

Con = control group = abdomen contracted, Exp = experimental group = abdomen relaxed, MRI = magnetic resonance imaging.
[a] Örebro Musculoskeletal Pain Questionnaire score > 50.

Adverse events

No adverse events related to the interventions were reported.

Discussion

This study aimed to investigate the effectiveness of Pilates exercises performed with either abdominal contraction or relaxation in people with chronic non-specific low back pain. The findings indicate that education to relax the abdominal muscles during Pilates exercises resulted in slightly greater improvement in disability compared with Pilates with education to keep the abdomen contracted. For the other outcomes (pain, patient-specific function and global perceived effect), the effect of keeping the abdomen relaxed during Pilates was roughly as good or mildly better than keeping the abdomen contracted. These results challenge the conventional emphasis on core activation in Pilates for chronic low back pain and present an alternative strategy to mildly improve efficacy of this intervention.

It is believed that this study was the first to investigate the effectiveness of education to relax the abdomen during Pilates exercises for chronic low back pain. Despite the emphasis on abdominal contraction during the Pilates exercises execution,[14,15] which is aimed at providing lumbar stability,[16,17] growing evidence suggests that excessive focus on core activation may reinforce maladaptive behaviours presented by people with chronic low back pain.[37,38] A systematic review by Smith et al[39] found that Pilates is beneficial for chronic low back pain, but improvements are not exclusively related to core activation. Furthermore, Stanton et al[40] emphasised that hypervigilance and excessive muscle guarding can contribute to pain persistence, highlighting the importance of movement variability and relaxation.

Beyond biomechanical aspects, psychosocial factors play a key role in the benefits of Pilates for chronic low back pain. An important mediation analysis by Wood et al[41] of a randomised controlled trial[11] explored how psychosocial mediators (such as self-efficacy, movement-related fear and pain catastrophising) impact the outcomes of Pilates in individuals with chronic low back pain. The study highlights that individuals with higher self-efficacy and lower fear-avoidance behaviours tend to experience greater improvements in pain and function. This aligns with the growing body of literature suggesting that chronic pain is influenced not only by biomechanical dysfunction but also by cognitive and emotional factors.[42–47]

Recent randomised trials suggest that specific parameters of Pilates delivery have limited influence on clinical outcomes in chronic low back pain. Studies comparing different weekly frequencies,[48] exercise intensities[49] and mat versus equipment-based Pilates[50] have reported similar effects on pain and disability outcomes. In line with this evidence, the current findings indicate that emphasising abdominal contraction is unnecessary. Overall, these results suggest that the benefits of Pilates for chronic low back pain are likely driven more by non-specific mechanisms than by specific technical aspects of exercise execution.

Pilates, by integrating controlled movement, concentration and breath control, may contribute to reducing maladaptive pain behaviours and fostering positive movement experiences. These aspects reinforce the importance of considering psychosocial interventions alongside physical training to maximise the therapeutic benefits of exercise in chronic pain populations.

The results provide further support for a more flexible approach to Pilates for chronic low back pain, where the focus shifts from rigid core engagement to overall movement quality and patient-centred adaptability. Breath control and concentration (which are key principles of Pilates) may be crucial mediators of its effectiveness, as suggested by recent motor control research.[51,52] Conscious abdominal bracing may restrict movement, elevate mechanical stress and increase energy expenditure;[53,54] therefore, this perspective is

Table 2
Mean (SD) of groups, mean (SD) within-group difference and mean (95% CI) between-group difference in pain, disability and patient-specific function.

Outcome	Groups				Within-group difference		Between-group difference[a] (95% CI)
	Week 0		Week 12		Week 12 minus Week 0		Week 12 minus Week 0
	Exp (n = 76)	Con (n = 76)	Exp (n = 76)	Con (n = 76)	Exp	Con	Exp minus Con
Pain scale *(0 to 10)*	7.1 (1.4)	7.3 (1.8)	3.5 (2.5)	4.1 (2.6)	−3.6 (2.3)	−3.1 (2.9)	−0.6 (−1.4 to 0.2)
RMDQ *(0 to 24)*	9.9 (4.7)	8.9 (3.9)	4.5 (3.9)	5.5 (4.7)	−5.2 (4.1)	−3.4 (4.3)	−1.4 (−2.6 to −0.2)
PSFS *(0 to 10)*	4.2 (1.7)	3.9 (1.7)	6.9 (1.8)	6.6 (1.8)	2.8 (2.3)	2.8 (2.3)	0.3 (−0.3 to 0.9)

Con = control group = abdomen contracted, Exp = experimental group = abdomen relaxed, PSFS = Patient-Specific Functional Scale, RMDQ = Roland-Morris Disability Questionnaire.
Higher scores indicate greater disease severity and negative between-group differences favour the experimental group, except for the Patient-Specific Functional Scale data.
[a] Adjusted using baseline values as a covariate.

Table 4
Mean (SD) of groups and mean (95% CI) between-group difference in global perceived effect.

Outcome	Week 12		Between-group difference (95% CI)
	Exp (n = 73)	Con (n = 70)	Exp minus Con
Global perceived effect *(−5 to +5)*	3.1 (1.7)	2.5 (2.1)	0.6 (−0.1 to 1.2)

Con = control group = abdomen contracted, Exp = experimental group = abdomen relaxed. Higher scores indicate greater perceived improvement and positive between-group difference favours the experimental group.

consistent with broader frameworks in pain science, emphasising movement confidence over hypervigilance.[55]

These findings suggest that educating patients to maintain abdominal relaxation during Pilates exercises may offer a slight additional improvement in disability and potentially mild improvements in other outcomes for people with chronic low back pain. This challenges the traditional emphasis on core contraction and supports a more flexible, patient-centred approach. Incorporating relaxation strategies into Pilates practice may reduce maladaptive muscle guarding behaviours and promote movement quality, aligning with contemporary pain neuroscience frameworks. These insights may inform physiotherapists and exercise professionals in optimising interventions for chronic pain management.

It is believed that this study is the first randomised trial to have investigated whether the instruction to relax abdominal muscles is better than the regular instruction to contract abdominal muscles in Pilates. Some strengths of this study were the adequate sample size, the intention-to-treat analysis and the very low loss to follow-up of participants. It was not possible to blind therapists and participants to the assigned treatment, given the nature of the intervention. This study did not investigate whether the improvement in disability was maintained at mid- and long-term follow-up.

We suggest that future studies explore long-term outcomes and investigate individual variability in response to different Pilates approaches. They should continue to optimise exercise-based interventions for chronic low back pain, considering individual variability and multidimensionality, and exploring the interplay between motor control, pain perception and psychosocial influences.

In conclusion, education to relax the abdominal muscles during Pilates exercises resulted in slightly greater improvement in disability compared with Pilates with education to keep the abdomen contracted in people with chronic non-specific low back pain. For the other outcomes (pain, patient-specific function and global perceived effect), the effect of keeping the abdomen relaxed during Pilates was roughly as good or mildly better than keeping the abdomen contracted. This study provides new insights into the role of abdominal relaxation in Pilates for chronic low back pain, challenging the traditional focus on core activation. The findings support a shift toward a broader approach, aligned with contemporary pain science and motor control perspectives, emphasising movement quality and psychosocial factors over rigid stability-focused approaches.

What was already known on this topic: Pilates-based exercise is recommended for people with chronic non-specific low back pain and has been shown to reduce pain and disability. Traditionally, Pilates emphasises activation of the core muscles during exercise to enhance spinal stability.
What this study adds: Instructing patients to keep the abdomen relaxed during Pilates exercises resulted in slightly greater improvement in disability than instructing them to keep the abdomen contracted. The effects of keeping the abdomen relaxed on pain, patient-specific function and perceived global effect were unclear; the confidence intervals ranged from roughly the same as keeping the abdomen contracted to a mild benefit from keeping the abdomen relaxed. These findings suggest that emphasising abdominal contraction may not be necessary when prescribing Pilates for people with chronic non-specific low back pain.

eAddenda: Table 3 can be found online at https://doi.org/10.1016/j.jphys.2026.03.007.

Ethics approval: The Human Research Ethics Committee from University Center of Lavras approved this study (CAAE 25669519.4.0000.5116, No. 3716573). All participants gave written informed consent before data collection began.

Competing interests: Nil.

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