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# The Effectiveness of Clinical Pilates in Adults with Chronic Low Back Pain

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## ABSTRACT

Chronic low back pain (CLBP) is one of the most common causes of functional impairments and disability, and the Pilates method has recently become a popular form of exercise for individuals undergoing rehabilitation. The effects of the Pilates approach in people with CLBP have been studied in several published researches. The purpose of this systematic review was to assess the effectiveness of Pilates method in pain, functionality, balance, flexibility and Quality of life (Qol), in adults with CLBP. A search for English Randomized Control Trials (RCTs) was undertaken using medical phrases and keywords for "Pilates" and "low back pain", within the last decade, in the PubMed database. One reviewer was involved in the selection of evidence, and from the 42 studies that emerged, 10 RCTs were included satisfying the eligibility criteria. A methodological quality assessment was also performed, using the PEDro scale and the mean score of the included RCTS was 6,7. The systematic review's findings indicated that a Pilates exercise programme as a rehabilitation, compared to no other intervention, in patients with CLBP or NSCLBP, results in short-term, statistically significant improvements in pain and functionality. The data supporting its effects in balance, flexibility and Qol are quite limited, as well as, the evidence regarding the superiority of the Pilates compared to other forms of physical exercise, are unclear. There are also, presented the limitations of this study and of the RCTs included in this systematic review. Overall, Pilates method has a greater improvement in pain and functional ability. Future studies should be conducted to support also the evidence about the positive effects of Pilates exercise in balance, flexibility and Qol, as well as, to examine the superiority of Pilates exercise compare to other forms of exercise.

***Keywords:*** Pilates, Chronic Low Back Pain, Exercise

## INTRODUCTION

Low back pain (LBP) is the most prevalent musculoskeletal disorder, with a high frequency of up to 84 percent in adult population. Chronic low back pain (CLBP) is a chronic pain syndrome that affects the lower back, lasts a period of at least three months and has a prevalence of 65% [1,2]. Despite the fact that spinal deterioration is a frequent part of aging, nearly 90% of LBP cases in primary care were not linked to a specific structural cause and as a result, non-specific LBP (NSLBP) was the classification of these cases [2]. LBP is a significant social and economic issue. Specifically, the annual prevalence of CLBP has been estimated to range between 15-45%, with a 30%-point prevalence. According to studies on CLPB, the average age-related incidence of persistent LPB in adults is around 15%, and also, over 27% in the elderly [3]. However, CLBP has doubled in prevalence in adults in the previous decade, is continuing to rise rapidly in the aging population, and both men and women of all ethnic groups, are affected [1].

Thus, it has a negative influence on work capability and welfare. LPB frequently leads

in a considerable deterioration of physical and psychological health, as well as, in a decline in the fulfillment of social duties such as job and family, when combined with rising health-care costs. Consequently, clinicians, patients, and policymakers continue to struggle with one of the most difficult musculoskeletal conditions to manage [3]. According to the scientific literature, to date, CLBP guidelines management suggest the use of anti-inflammatory drugs, weak opioids for short-term use, physical exercise, spinal manipulation, and health-promoting activities in general. Multidisciplinary rehabilitation, supplementary analgesics, cognitive behavioral therapy, and powerful opioids are all secondary recommendations. However, many treatments' mechanisms of action are unknown, and most treatments have small effect sizes [4,5]. Regarding the Pilates method, although limited, several studies suggest that in a short-term period, provides faster functional recovery compared to minimal physical exercise intervention for disability and pain reduction in CLBP disorder, as well as, the same long-term results as general exercise [2,6].

**Background**

LBP is divided into three types: axial lumbosacral, radicular, and referral pain. Back discomfort in the lumbar, or L1-5 vertebral region, and sacral spine, or S1 to sacrococcygeal junction region, is known as axial lumbosacral back pain. Because of nerve or dorsal root ganglion stimulation, radicular leg pain goes into an extremity along a dermatomal distribution. Referred pain travels via a non-dermatomal path to an anatomical region distant from its origins [4]. Furthermore, LBP can be classified as acute (less than 6 weeks), subacute (6-12 weeks), or chronic (more than 12 weeks), depending on the chronicity of the condition. CLBP is defined ''as LBP that lasts longer than 12 weeks, with one-third of all low back patients experiencing moderate-intensity LBP a year after an acute episode''. ''Yellow flags'' are risk factors for chronic condition. LBP chronicity is strongly predicted by psychosocial and emotional components. Additionally, several studies support also, as one of the predominant, the occupational factor for the progression of the CLBP [3,7].

During the clinical assessment of a patient with lower back symptoms, it is probable that a precise cause will not be identified because up to 85% of patients are diagnosed with non-specific LBP from the outset. To properly diagnose the type of LBP, it is necessary to seek for evidence of particular etiologies of back pain. LBP can often be distinguished based on a patient's medical history, physical examination, and in rare situations, imaging. For example, among fibromyalgia patients, muscle tension and spasm are among the most common causes of LBP. In other circumstances, LBP is caused by a variety of pain generators, each with its own set of features, such as radicular, facet joint, sacroiliac, and discogenic pain, as well as spinal stenosis [1,7]. Moreover, alterations in fiber type in the Multifidus and erector spinae are thought to be possible variables in the etiology and/or recurrence of pain symptoms in patients with LBP since it has a negative impact on muscle strength and endurance. It has been suggested that type I fibers are more influenced by pain and immobility than type II fibers in the latter situation [8].

The Pilates method is a popular kind of exercise that is advised for both healthy people and those who are recovering from an injury. The equipment used during therapeutic sessions and the method in general, was created by Joseph Pilates in 1920s and ''Centrology'' was the initial term for this method [9,10]. It combines Asian and Western practices to promote core stability, muscle control, range of motion (ROM), strengthening and flexibility, posture (proprioception), as well as, breathing coordination [9,10]. More specifically, to stabilize the pelvic-lumbar area, the Pilates approach incorporates

deliberate use of trunk muscles. Co-contraction of the multifidus (a deep back muscle), transversus abdominis (a deep abdominal muscle), pelvic floor, and diaphragm muscles is noted during dynamic Pilates activities. Co-contraction of these muscles has the purpose of reducing joint compression and changing pelvic tilt. These exercises can be performed with the use of specific equipment (equipment-based Pilates), or without respectively (mat Pilates) [9,10].

One physiologic explanation for how Pilates exercises might function in LBP rehabilitation is that individuals with LBP have abnormal spinal muscle stability and control. According to available evidence, in individuals with LBP, two motor control deficiencies are thought to occur: first, when the spine's stability is tested in dynamic tasks, the initiation of activity of deep muscles like the multifidus and transversus abdominis is delayed [10]. Second, LBP patients often compensate for their lack of stability by increasing their superficial muscle activity and this causes the spine to become stiffer. The Pilates approach advocates workouts that target these two variables (increasing spinal stability by improving deep muscle motor control while decreasing superficial muscle activity), as well as, improving posture and body awareness. These characteristics may help people with LBP improve their function, pain, balance, flexibility and Qol [2,10].

For this reason, the aim of this systematic literature review is to explore the effectiveness of Pilates exercise programmes in adults with CLBP or NSCLBP, and to investigate the following research questions: a) Does a Pilates exercise programme reduces significantly pain in adults with CLPB? b) Does a Pilates exercise programme improves significantly function, balance, flexibility and quality of life (Qol) in adults with CLBP over time? From the above-mentioned research questions are developed the following research hypothesis: The Alternative hypothesis (H1), which is that "A Pilates exercise programme is effective in reducing pain, improving function, balance, flexibility and Qol in adults with CLBP'', and the Null hypothesis (H0), which is that "A Pilates exercise programme is not effective in reducing pain, improving function, balance, flexibility and Qol in adults with CLBP''. This systematic literature review is not relevant to the effectiveness of Pilates exercise programme on acute and subacute LBP. Further down is expounded the methodology was adopted in order the results to be obtained and analyzed, are presented the extensive literature review results and are critically discussed the conclusions, the study limitations and the future recommendations needed.

## MATERIALS & METHODS

The current study project's development belongs to the category of Systematic Reviews. This review attempts to incorporate data from legitimate English Randomized Controlled Trial (RCTs) articles, published between October 2015 and April 2019, so as to include new rather than old scientific evidence, related to the effectiveness of Pilates exercise programmes, as a rehabilitation method, in patients with CLBP and NSCLPB.

### Research strategy

The method was followed, was an advanced literature review, performed for English Randomized Controlled Trial articles across PubMed database. The following keywords and medical terms were used in the search for the desired data on this topic: ''Pilates'', ''Pilates method'', ''Clinical Pilates'', ''exercise'', ''exercise programme'', ''low back pain'', ''back pain'' ''chronic'', ''non-specific'', ''effectiveness'' and ''rehabilitation''. A variety of keyword combinations were utilized to discover the most relevant and appropriate articles.

### PubMed database search results

The first two algorithm combinations that were implemented were as follows:

‘‘((Pilates method) AND (low back pain)) OR (chronic low back pain)’’ and ‘‘((Clinical Pilates) AND (low back pain)) OR (back pain)’’, which yielded in total 9.475 potentially relevant citations. Similarly, the algorithm combinations between the third and the seventieth searches were ‘‘(Pilates) AND (low back pain rehabilitation)’’, ‘‘(Pilates effectiveness) AND (low back pain)’’, ‘‘(Pilates exercise programme*) AND (low back pain)’’, ‘‘(Pilates exercise) AND (low back pain)’’ and ‘‘((Pilates) AND (low back pain)) OR (non-specific low back pain)’’, which were more specific and yielded in total 158 relevant results. The filters were applied in the above-mentioned algorithm combinations were: Abstract, Clinical Trial, Randomized Controlled Trial. The final algorithm combination was used was the ‘‘(Pilates) AND (low back pain)’’, which yielded 42 related citations and the following filters were applied: Abstract, Clinical Trial, Randomized Controlled Trial, in the last 10 years, English, Adult: 19+ years, in order to further reduce the number of results (29), and the heterogeneity of the RCTs.

After reviewing the 29 article titles and abstracts against predetermined qualifying criteria (listed below), 13 articles were eliminated, including those that did not report a relevant intervention or outcome, as well as those that were associated to pregnant women or another condition. Following the second full text comprehensive screening of the 16 acceptable articles, six articles were eliminated, and so it remained ten. In particular, was excluded one that pertained to a research subject for which there was more recent study with the same variables and outcome measures, three that had poor methodological quality and level of evidence compare to the other articles, and two in which there was no control group, and different Pilates techniques were compared with each other. The found articles were examined with the steps mentioned in the flow chart (Figure 1.).

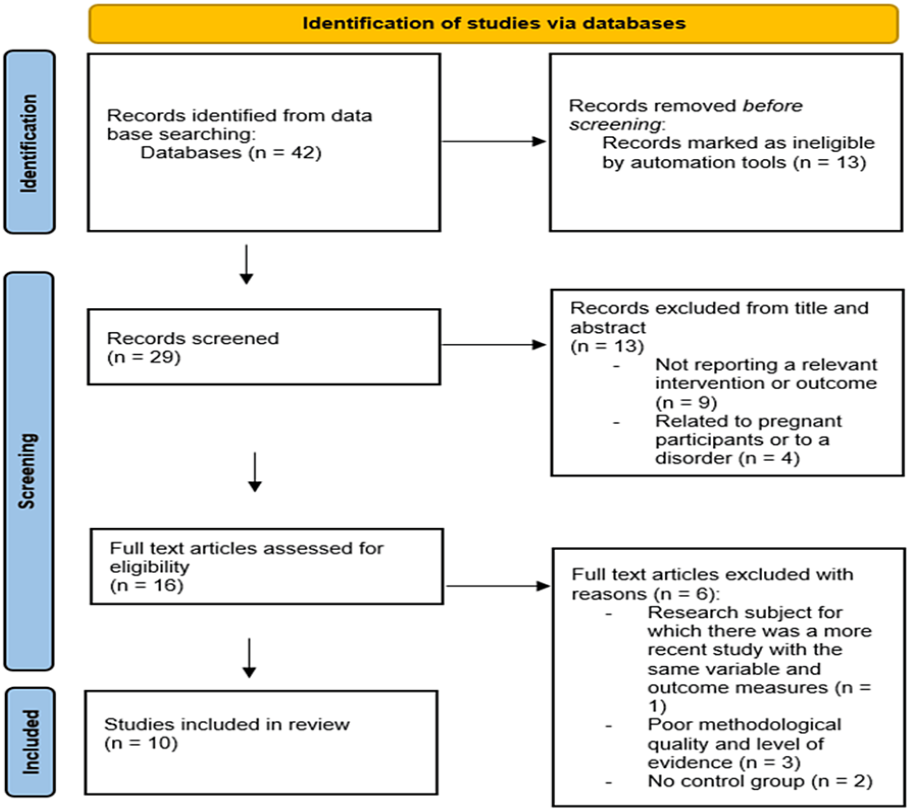


**Figure 1. PRISMA Flow Chart**

**Inclusion and Exclusion criteria**

The inclusion criteria for conducting this systematic review, in terms of the selection of studies, were the following: a) the studies to have been published in legitimate scientific publications (surveys on sites of questionable quality and validity were excluded), b) the articles to be only English RCTs, c) the RCTs to have been published for the last decade, d) the participants in the research articles to have been adults (both male and female) aged 18 and older, e) with history of CLBP or NSCLBP lasted > 12 weeks, f) with or without referred lower extremity pain, LBP to have been defined as discomfort or pain located below the costal edge and above the inferior gluteal folds, g) the intervention type in the articles had to be only related to Pilates method, h) the therapists who delivered the interventions in the studies they had to be either certified Pilates teachers or to have had prior experience in Pilates exercises, i) the diagnosis of the CLBP had to be by a physician or a physiotherapist, j) RCTs should definitely include one or two of the three outcome measures considered in this systematic review, k) all studies' participants to have given their informed consent in accordance with Declaration of Helsinki, and l) participants to had the sufficient physical autonomy to participate in the study's physical activities.

Regarding the exclusion criteria: a) articles with participants who were unable to exercise due to a medical condition, b) articles related to acute LBP, c) articles related to LBP and pregnancy, d) articles with participants who had a significant spinal condition (i.e., surgery, cancer, fracture, cauda equina syndrome and inflammatory diseases, stenosis, tumors) or diagnosis of LBP due to other causes (i.e., fibromyalgia, lawsuit), e) articles with participants who had other serious pathologies such as, history of vestibular disorders, neurological, respiratory disease, psychological condition, f) articles in which the participants were in a condition that could affect their balance, and g) articles with participants who had practiced Pilates or any other specific exercise program on a regular basis in the last 6 months.

**Quality assessment**

The PEDro scale, which consists of 11 elements linked to the validity of the articles reviewed, was used to assess the methodological quality of the included studies (De Morton, 2009). The first item is related to external validity, but it is not counted into the final score. Internal validity is the subject of the remaining items. Randomization, allocation concealment, baseline comparability, blinding of therapists, patients, and raters, experimental mortality, intention-to-treat analysis, statistical comparisons and point measures, and measures of variability are all covered in this section. These items may help readers select studies that are likely to be internally valid (items 2-9) and studies that have enough statistical information to make their findings interpretable (items 10-11) [11]. The PEDro's ultimate score may vary from 0 (poor quality) to 10 (excellent quality). Studies that scored 6 in the PEDro were categorized as studies with high methodological quality based on the procedure of previous studies [12,13].

## RESULT

The current literature is quite extensive with respect to data describing the effectiveness of Pilates exercise programmes (mat or equipment-based), as a rehabilitation method in patients suffering from CLBP or NSCLBP. Most of the articles focus solely on the effectiveness of Pilates compared to no treatment at all, and in addition, more limited citations with regard to the effectiveness of Pilates method combined with physical therapy are observed, as well as, compared to other form of exercise. Through the advanced literature search was performed, it seemed that probably, Pilates method improves pain, balance, flexibility, functionality and Qol in patients with CLBP, for this reason the evaluation and

examination of these five specific outcomes was followed.

In Table 1 is depicted the methodological quality assessment for the included studies, using the PEDro scale. With a mean score of 6,7 the PEDro risk of bias evaluation revealed that 80% of the included studies were of high quality. The scoring of studies for the risk of bias ranged from 5 to 8. Eight of the eligible studies presented high methodological quality [6, 14, 15, 16, 17, 18, 19, 20]. While the rest of the included studies had moderate quality [21, 22]. All studies satisfied the items that were related to random allocation, between-group comparison, and the point estimates and variability, whereas the majority of the studies satisfied the items related to concealed allocation, baseline comparability, blinding of assessors and adequate follow-up.

| Studies | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Total score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mostagi et al., 2014 [14]** | Y | Y | Y | Y | N | N | Y | N | Y | Y | Y | 7 |
| **Cruz-Díaz et al., 2015 [15]** | N | Y | N | Y | N | N | Y | Y | N | Y | Y | 6 |
| **Cruz-Díaz et al., 2015 [16]** | Y | Y | Y | N | N | Y | Y | Y | Y | Y | Y | 8 |
| **Natour et al., 2015 [18]** | N | Y | Y | Y | N | N | Y | Y | Y | Y | Y | 8 |
| **Kofotolis et al., 2016 [21]** | Y | Y | Y | Y | N | N | N | N | N | Y | Y | 5 |
| **Valenza et al., 2016 [19]** | Y | Y | Y | Y | N | N | Y | Y | Y | Y | Y | 8 |
| **Lopes et al., 2017 [20]** | N | Y | Y | Y | N | N | Y | Y | N | Y | Y | 7 |
| **Mazloum et al., 2017 [22]** | N | Y | N | Y | N | N | Y | N | N | Y | Y | 5 |
| **Cruz-Díaz et al., 2018 [17]** | Y | Y | Y | Y | N | N | Y | Y | N | Y | Y | 7 |
| **Amaral et al., 2019 [6]** | Y | Y | N | Y | N | N | Y | Y | N | Y | Y | 6 |

**Table 1: Methodological quality assessment using the PEDro scale**

To evaluate the similarity or heterogeneity of the 10 RCTs that emerged from the literature search and review process, a table (Table 2) was formed, which includes the authors' names, the study's sample characteristics, the interventions that were implemented, the duration of the interventions, the evaluation of the outcome measures, and the results of each intervention method.

| Studies | Number of participants | Interventions | Period (wk) | Outcome measures | Result |
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| Mostagi et al., 2014 [14] | Pilates group (n=11) General exercise group (n=11) | - Pilates group: 1) One-hour individual/private session 2) A direction-specific exercise program: basic principles of Pilates (concentration, control, centering, flow, precision and breathing), Fundamental movements (breathing, pelvic bowl, knee sway, spinal bridge, twist, flight and cat) + matt, chair, Cadillac, Swiss ball, reformer exercises for postural alignment, trunk control etc. - General exercise group: 1) one-hour individual/private session 2) Standardized generic exercises for the management of Chronic Low Back Pain (stationary bicycling, trunk and lower limb stretching, spine mobilization and trunk muscle strengthening). | Sixteen sessions, 2 days/week for 8 weeks. | - Pain: Visual Analog Scale (VAS) - Functionality: Quebec Back Pain Questionnaire - Flexibility: kinematic analysis measuring the hip joint angle. - Endurance of the trunk extensor muscles: Sorensen test. | There were no statistical differences between the Pilates and general exercises groups with regard to pain and functionality in Non-Specific Chronic Low Back Pain subjects, but general exercises were better than Pilates for increasing functionality and flexibility. |
| Cruz-Díaz et al., 2015 [15] | Physiotherapy or Pilates group (n=50) Physiotherapy-only group (n=47) | - Physiotherapy or Pilates group: 1) Application of TENS with a pulse frequency of 100 Hz for 40 min, and 20 min of massage and stretching of the low-back zone. 2) Pilates exercise training (one hour per session). - Physiotherapy-only group: same intervention with Physiotherapy or Pilates group, | 2 days/week (PT) + 2 days/week Pilates, for six weeks. | - Fear of falling (FoF): The Falls Efficacy Scale-International (FES-I) - Functional mobility and balance: Timed Up and Go Test (TUG) - Pain | FoF decreased significantly after six weeks of intervention only in the Pilates group. Functional mobility and balance improvement was observed only in the Pilates group, and also, both interventions were effective in the management of lumbar pain intensity, with |

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| | | without the Pilates exercise training. | | intensity: Numeric Rating Scale (NRS) | statistically significant difference in the Pilates group, compared to the only-physiotherapy group. |
| Cruz-Díaz et al., 2015 [16] | Pilates + physical therapy (PPT) group (n= 53) Physical therapy (PT) only group (n= 48) | Pilates + Physical Therapy group: 1) Pilates programme (strengthening exercises with fitballs, magic rings and TheraBands, flexibility and joint mobility exercises, breathing exercises, and motor control and posture correction tasks (1 hour session). 2) TENS (100 Hz, 200 ms for 40 min), Joint mobilizations (oscillation frequency of 1 to 2 Hz during 30 s in the hypomobile or painful lumbar segment for 10 min approximately). - Physical Therapy group: same intervention with Pilates + Physical Therapy group, without the Pilates exercise. | 2 days/week for 6 weeks. | - Pain graduation: Numeric Rating Scale - Functional impairment/ disability: Oswestry Disability Index (ODI) | There were significant differences in pain and disability after 6 weeks of treatment in both groups, with higher improvement in the Pilates + Physical Therapy group. A statistically significant decrease in disability and pain was observed, after treatment and 1-year follow-up in the Pilates + Physical Therapy group. |
| Natour et al., 2015 [18] | Experimental group (n= 30) Control group (n= 30) | - Experimental group: 1) use of non-steroidal anti-inflammatory drugs (NSAID). 2) Pilates exercise programme (50 min). - Control group: only use of NSAID. | 2 days/week for 13 weeks. | - Pain: VAS - Function: Roland-Morris questionnaire - Quality of life: 36-Item Short Form Survey (SF-36) - Satisfaction with treatment: Likert scale - Flexibility: sit and reach test. - NSAID: recorded on a chart. | Statistically significant difference favoring the experimental group regarding pain, function, and some Quality of life domains, was observed. No significant differences were found between two groups regarding satisfaction with treatment, however, a statistically significant difference was found in the use of NSAID, in favour of the experimental group. |
| Kofotolis et al., 2016 [21] | Pilates group (n=37) Trunk strengthening exercise group (n= 36) Control group (n= 28) | - Pilates group: Mat Pilates exercise program (warm-up lasting 5-10 min including walking, stretching of low back muscles, general stretching, and then 16 exercises for core stability, proper alignment of the pelvis and lumbar spine, breathing and movement control, strength and performance through full ROM, cool-down exercises 5–7 min including walking at slow pace and stretching exercises). - Trunk strengthening exercise group: warm-up lasting 5-10 min including walking, stretching of low back muscles, general stretching and then exercises for the abdominals, for the back extensors, and for the rest of the body, cool-down exercises 5–7 min including walking at slow pace and stretching exercises. - Control group: participation in their daily activities. - A total of 24 sessions (1 hour) | 3 days/week for 8 weeks. | - Health related Qol and pain: SF-36 - LBP-related functional disability: Roland Morris Disability Questionnaire | Both Pilates program and trunk strength exercises improved Health related Qol and reduced functional disability, however, a greater statistically difference for the Pilates group compared to the trunk strengthening exercise group was observed. |
| Valenza et al., 2016 [19] | Experimental group (n= 27) Control group (n= 27) | - Experimental group: 45 min session of Pilates exercise programme (basic introduction to the Pilates-based exercises, core muscle activation with breathing control, floor exercises using a 55-cm ball on a rubber mat, and 3-5 min of relaxation at the end using a rubber roller). - Control group: | 2 days/week for 8 weeks. | - Disability: Morris Disability Questionnaire & ODI - Pain intensity: VAS - Lumbar mobility: Modified Schober test. - Flexibility: finger-to floor test. - Balance: | Statistically significant difference was observed between the two groups for disability, pain, flexibility and balance, in favor of the experimental group. |

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| | | continued their usual activities and received advice in the form of a leaflet (postural care, physical activity, lifting weights etc.). | | single-limb stance test. | |
| Lopes et al., 2017 [20] | Pilates group (n= 23) Control group (n= 23) | - Pilates group: 20 min sessions (4 exercises – the single leg stretch, the pelvic press, swimming, and opposite arm and leg reach, for strengthening deep stabilizer muscles, hip extensors, and reinforcing in general stability of the lower back, pelvis and hip during movement and assisting the hip strategy). - Control group: rested in sitting position. | A single session | - Daily physical activity: short-form of the International Physical Activity Questionnaire. - Disability: ODI V2.0 - Pain intensity: VAS - Postural control: Star Excursion Balance Test (SEBT). - Postural sway: force platform. | An immediate statistically significant improvement was observed in the Pilates group regarding the postural sway and the dynamic balance, in comparison to the control group. Pain also decreased significantly in the Pilates group, while no changes were observed in the control group. |
| Mazloum et al., 2017 [22] | Selective Pilates (SP) training group (n= 16) Extension based (EB) exercises group (n= 15) Control group (n= 16) | - Selective Pilates training group: shoulder bridge, side kick, one leg stretch, hundred, roll up, swine dive, swimming, one leg circle, double arm stretch, spine twist (gradual increase in the degree of difficulty). - Extension based exercise group: deep breathing in prone, passive trunk extension on elbows in prone, passive trunk extension on hands in prone, passive trunk extension in standing, knee to chest in crook lying, trunk flexion in sitting on a chair. - Control group: continued their daily activities. | 3 days/week for six weeks. | - Pain intensity: VAS - Physical disability: ODI - Forward flexion ROM of the lumbar spine: modified Schober test - Lumbar curvature: flexible ruler. | More significant improvement was observed in Selective Pilates group compared to the subjects receiving Extension based exercises in terms of pain, ROM, and physical disability, however, there was no significant difference between the two experimental groups for lumbar curvature. Furthermore, in follow-up, the patients in Selective Pilates group significantly achieved a higher level of pain intensity improvement and lumbar flexion ROM than the Extension based exercises. |
| Cruz-Díaz et al., 2018 [17] | Pilates group (n= 32) Control group (n= 32) | - Pilates group: 50 min Pilates mat sessions (warm-up with breathing exercises, pelvis tilt centering, deep trunk and pelvic floor muscles activation and joint mobility, strength and flexibility exercises involving the trunk, upper and lower limbs, cool down with some stretching exercises). - Control group: booklet with chronic non-specific low back pain information. | 2 days/week for 12 weeks. | - Disability: Roland Morris Disability Questionnaire - Pain: VAS - Fear of movement/injury or reinjury: Spanish version of the Tampa Scale of Kinesiophobia. - Transversus abdominis activation: real-time ultrasound scanning. | All variables, except the transversus abdominis, improved significantly in the group of Pilates with respect to control group, both at 6 to 12weeks postintervention. |
| Amaral et al., 2019 [6] | Educational booklet group (n= 74) Pilates group (n= 148) | -Pilates group: 1) Educational booklet containing information about LBP, anatomy of the spine and recommendations related to activities of daily living and posture. 2) Pilates principles instructions and training for the activation of the deep abdominal muscles while exhaling, during all exercises + 5 min warm-up (breathing and mobility exercises), 50 min of Pilates-based exercises (stretching and strengthening exercises for muscles of the trunk, lower and upper limbs), and 5 min of cool down (relaxation exercises and massage with ball). - | 2-3 days/week for six weeks. | - Pain intensity: Pain Numeric Rating Scale (PNRS) - Disability: Roland Morris Disability Questionnaire | None of the interaction terms for pain and disability were statistically significant. Thus, the effect of treatment (Pilates versus an educational booklet) was similar in all subgroups. |

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| | | Educational booklet group: they received also, the educational booklet, but no additional treatment. | | | |

**Table 2: Characteristics of included studies**

NSAID: non-steroidal anti-inflammatory drugs, ROM: Range of Motion, Qol: Quality of Life, LBP: Low Back Pain, SF: Short Form survey, ODI: Oswestry Disability Index, VAS: Visual Analogue Scale

## LITERATURE REVIEW OUTCOME MEASURES - RESULTS

### Pain and function/physical disability

In all of the ten studies that were emerged from the literature search and the screening process, the main outcomes that were measured in subjects with CLBP or NSCLBP before and after the intervention, was the pain intensity and the functional mobility/disability. More specifically, the Mostagi et al. [14], executed an 8-week protocol, aiming to evaluate the efficiency of the Pilates technique compared to general exercises in terms of pain and functionality in patients with NSCLBP after eight weeks and a three-month follow-up. Both male and female subjects aged 18-55 years were randomized to a Pilates group (n= 11) or to a general exercise group (n=11). The subjects received sixteen sessions per week, twice a week. The interventions consisted of a one-hour individual/private session for both groups.

The Pilates group performed a direction-specific exercise program with basic principles of Pilates (concentration, control, centring, flow, precision and breathing), fundamental movements (breathing, pelvic bowl, knee sway, spinal bridge, twist, flight and cat) and matt, chair, Cadillac, Swiss ball, reformer exercises for postural alignment, trunk control etc. The general exercise group performed standardized generic exercises for the management of CLBP (stationary bicycling, trunk and lower limb stretching, spine mobilization and trunk muscle strengthening). The VAS was used to assess the primary outcome, which was pain. The Quebec Back Pain Questionnaire was also used to assess patient functionality, which was a secondary outcome. Regarding the study results, there were no statistical differences in pain and functionality between the Pilates and general exercises groups in patients with NSCLBP, however general exercises were superior than Pilates for enhancing functionality and flexibility.

In addition, the Cruz-Díaz et al. [15], implemented a six-week Pilates protocol, in woman aged over 65 years with CLBP, in order to investigate the effects of the Pilates method in pain intensity and in functionality. Patients were randomly assigned to either a physiotherapy and Pilates group (n= 50), or a physiotherapy-only group in the trial (n= 47). Both groups received the same physiotherapy intervention twice a week, with the physiotherapy and Pilates group receiving additional Pilates exercise training (PPTG). The treatment for the physiotherapy-only group (PTG) included 40 minutes of TENS, with a pulse frequency of 100 Hz and 20 minutes of massage and stretching of the low-back zone. The PPTG also received two weekly Pilates sessions in addition to their treatment (one hour per session). Patients were assessed at the baseline of the treatment, and again after six weeks. The NPRS was used as a measurement tool to assess the pain intensity and the TUG test was used as a measurement tool to assess the functional mobility of the participants. The study results indicated that only the Pilates group demonstrated statistically significant improvement in functional mobility, and both therapies were successful in reducing lumbar pain intensity, with the Pilates group showing higher effects.

Another study of the Cruz-Díaz et al. [16], which was aimed to compare the short- and long-term effectiveness of Clinical Pilates combined with physical therapy to physical therapy alone in a group of postmenopausal women suffering from persistent CLBP,

indicated also, significant differences between groups in pain and disability after six weeks of treatment and after 1-year follow-up, with better results in the Pilates and physical therapy group. Female patients aged between 45-75 years, were randomly allocated to either a Pilates group (n= 53), which would receive six weeks of Pilates practice in addition to twice-weekly physical therapy, or to a control group (n= 48), which would only receive the same physical therapy treatment. Strengthening activities employing equipment such as fitballs, magic rings, and TheraBands, flexibility and joint mobility exercises, breathing exercises, and motor control and posture correction tasks were all part of the one-hour Pilates sessions.

During the intervention, the training load was adjusted by doing several variants of the same exercise as considered in Pilates, depending on the patients' physical performance level. Analgesic electrotherapy and lumbar spine joint mobilization were used as part of the physical therapy. TENS was used for electrotherapy, with a pulse frequency of 100 Hz, a pulse duration of 200 ms, and a 40-minute application time. Manual treatment was used in a posteroanterior joint mobilization based on Maitland principles for 10 minutes in the hypomobile or painful lumbar segment with an oscillation frequency of 1 to 2 Hz for 30 seconds in the hypomobile or painful lumbar segment. Pre- and post-treatment pain graduation was determined using an NRS, as well as, for the assessment of the functional status in relation to LBP, the ODI was used.

Additionally, the study of Natour et al. [18], executed a 13-week protocol with the purpose of investigating the effectiveness of the Pilates method on patients with NSCLBP. Both male and female patients aged 18 to 50 years, were randomly allocated to one of two groups: Experimental Group (n= 30), who continued their medication therapy with NSAID and received Pilates treatment, or Control Group (n= 30), who continued their medication treatment with NSAID, but did not receive any further intervention. Pilates courses were 50 minutes long and followed a pre-determined Pilates regimen. They were held twice a week for a total of 90 days. When needed, patients in both groups were directed to take 50mg sodium diclofenac at intervals of no less than 8 hours (VAS for pain more than 7cm). Throughout the trial, patients were also encouraged to keep track of how many medicines they took each day on a sheet. The pain was measured with the VAS, and the function with the Roland-Morris questionnaire respectively. The study results indicated that there were statistically significant differences favoring the Experimental group in terms of pain and function, as well as, between groups in terms of pain medication use, with the Experimental group using fewer NSAIDs than the Control Group.

Furthermore, the Kofotolis et al. [21], conducted research with the aim to investigate how a Pilates program compared to a trunk strengthening exercise program affected functional impairment and health-related quality of life (HRQOL) in women with NSCLBP. Female patients aged 25 to 65 years, were randomly assigned to either a Pilates (n = 37), trunk strengthening (n = 36), or control group (n = 28) for an 8-week, three-times-a-week workout. Both programs included 24 one-hour sessions, with each beginning with a 5- to 10-minute warm-up that included walking, stretching of the low back muscles, and general stretching. Each training session included 5-7 minutes of cool-down exercises, which included gentle walking and stretching exercises. The aim of the Mat Pilates exercise programme was to improve core stability and proper pelvic and lumbar spine alignment, and it was based on the basic Pilates concepts of breathing control, correct postural alignment, precision, flow, and control of movement, trunk stability and strength, and full range of motion exercise performance. Roll down, mermaid, spine stretching, pelvic curl, criss-cross, double leg stretch, hundreds, double knee folds, table top,

swimming, swan, cat stretch, child's pose, hips stretch were all part of the Pilates protocol.

The trunk strengthening workout program designed to improve the strength and flexibility of abdominal and back muscles. There were specific exercises for the abdominals (upper and oblique abdominals, lower abdominal crunches, abdominal curls, etc.), for the back extensors (lifting trunk to neutral from prone position and arms in elevation, single-leg trunk extensions etc.), and for the rest body (straight leg lifts toward ceiling, alternate arm/leg lifts sitting on a Swiss ball etc.). Except from their daily activities, participants in the Control group did not engage in any type of structured exercise or physical activity. The SF-36 was used as a measurement tool for the pain, and the LBP-related functional disability was evaluated with the Roland Morris Disability Questionnaire. Regarding the results of the research, when compared to participants in the trunk strengthening exercise and control groups, Pilates participants reported greater statistically significant differences in pain levels and in functional disability. Furthermore, the Pilates group's results lasted three months after the programme ended, while the trunk strengthening exercise group's effects lasted only a month.

Moreover, the Valenza et al. [19], implemented an 8-week treatment protocol, in order to investigate how a Pilates exercise programme affects individuals with persistent NSCLBP, in terms of disability and pain. Both male and female patients aged between 18 and 70 years, were randomly allocated to an experimental group (n=27) or to a control group (n=27). The experimental group was required to participate in a Pilates exercise program twice a week. The sessions were 45 minutes long each, and all participants were given a basic introduction to the Pilates-based exercises and were taught how to activate the core muscles, while exhaling during diaphragmatic breathing. The Pilates protocol included floor exercises with a 55-cm ball on a rubber mat, such as spine stretches, saw, mermaid, one-leg stretch, double-leg stretch, crisscross, swan dive, swimming, spine twist, one-leg kick, double-leg kick, shoulder bridge, one-leg circle, side kick, and 3 to 5 minutes of relaxation with a rubber roller at the end. The patients in the control group were instructed to continue their daily routines as usual and were given guidance in the form of a leaflet. Postural correction, physical activity, lifting weights, sedentary activities, sports, pain-free maximal physical activity level, behavioral counseling, fear of movement, erroneous attitudes, and an active lifestyle were all covered in the leaflet. As a measurement tool for the evaluation of the disability was used the Roland-Morris Disability Questionnaire and the ODI, and for the pain the VAS respectively. Concerning the study results, the between-group analysis revealed statistically significant differences in disability scores and mean difference in pain levels in the intervention group compared to the control group.

The Lopes et al. [20] executed also, a study aiming to determine the immediate effect of one session of Pilates exercises in young adults who had NSCLBP. Both male and female patients aged 18 and older, were randomized to a Pilates group (n= 23) and to a control group (n= 23). The Pilates group intervention included the Pilates key-principals (alignment, breathing and hollowing-in) and four exercises: single leg stretch, pelvic press, swimming, and opposite arm and leg reach (bird dog). The workouts were designed to strengthen deep stabilizer muscles and hip extensors. This study was focused on the particular activation of hip muscles, in order to maintain general lower back, pelvis, and hip stability during mobility, as well as to support the hip strategy, which is hindered in patients with NSCLBP on an unstable ground. The exercise session lasted 20 minutes, and participants in the control group sat in the same position for the same amount of time. The participants from both groups were evaluated before and after the

Pilates session or the control period. Pain intensity was assessed with the VAS, and disability was quantified with the ODI version 2. Regarding the results of the research, the pain was statistically significant reduced after the Pilates workout, whereas pain levels in the control group did not change. However, no difference was found between the two groups in disability after the intervention.

The Mazloum et al. [22] executed also, a study aiming to compare the effects of selective Pilates (SP) and extension based (EB) exercises, in individuals with NSCLBP. Both male and female adults between the age 18-55 years old, were randomly allocated into either SP (n= 16), EB (n= 15), or control (N= 16) groups. The subjects were given SP and EB exercises three times a week for six weeks. The treatment protocol for the SP training group included exercises such as, shoulder bridge, side kick, one leg stretch, hundred, roll up, swine dive, swimming, one leg circle, double arm stretch and spine twist, with gradual increase in the degree of difficulty, and as for the EB exercise group, exercises such as, deep breathing in prone, passive trunk extension on elbows in prone, passive trunk extension on hands in prone, passive trunk extension in standing, knee to chest in crook lying and trunk flexion in sitting on a chair. The measurement tool for the pain intensity was the VAS, and for the physical disability, the ODI respectively. The study results indicated that in terms of pain and physical disability, the SP group showed a greater statistically improvement than the participants who received EB exercises. Furthermore, when compared to the EB exercises, the patients in the SP group had a significantly higher level of pain intensity improvement at the follow-up.

Additionally, the Cruz-Díaz et al. [17], conducted again another study, with the purpose of evaluating the effectiveness of a 12-week Pilates programme in patients with NSCLBP. Both male and female participants aged between 18 to 50 years were randomly allocated to into an experimental (n= 32) or control group (n=32). Patients in the experimental group received a Pilates intervention consisting of two 50-minute sessions per week. The intervention was divided into three main parts. Warm up with breathing exercises, pelvis tilt centering, deep trunk and pelvic floor muscle activation, and joint mobility at the start of each session. Strength and flexibility exercises involving the trunk, upper and lower limbs were the principal parts of the Pilates session. Finally, there was a cool-down phase that included some stretching exercises. To reduce potential dropout and disappointment from not receiving treatment, patients in the control group were given a booklet containing general CLBP information. Outcomes were assessed with the measurement tools at baseline prior to the beginning of the intervention, after 6 and 12 weeks of treatment. Pain was measured using the VAS, and disability using the Roland Morris Disability Questionnaire. Concerning the study results, there were significant differences across groups, with the Pilates intervention group showing improvement in pain and disability. Specifically, after six weeks of intervention, there were significant changes in disability, but after 12 weeks, there was no significant difference. Pain was improved after six weeks, with a small but statistically significant improvement after twelve weeks.

Finally, the Amaral et al. [6], implemented a six-week intervention protocol, in order to examine the effectiveness of Pilates-based exercise compared to an educational booklet in patients with CLBP. Both male and female patients aged between 18 and 80 years were randomized to either on an educational booklet group (n= 74) or to a Pilates group (n=148). The Pilates class was given an informative leaflet that included information on LBP, the anatomy of the spine, and guidelines for everyday activities and posture. Moreover, the Pilates group attended a Pilates exercise programme 2-3 times per week, in which were included principles instructions and training for the

activation of the deep abdominal muscles while exhaling, during all exercises, 5 minutes warm-up (breathing and mobility exercises), 50 minutes of Pilates-based exercises (stretching and strengthening exercises for muscles of the trunk, lower and upper limbs), and 5 minutes of cool down (relaxation exercises and massage with ball). The educational booklet group received also, the educational booklet, but no additional treatment. Pain was measured using the PNRS, and disability using the Roland Morris Disability Questionnaire. The study results indicated that none of the pain and disability interaction variables were statistically significant and thus, that the treatment impact was equal across the Pilates and the educational booklet group.

**Flexibility, Balance and Qol**

Three of the ten studies that emerged from the literature review assessed also, the flexibility and the balance as outcomes, as well as, two of the ten studies evaluated the Qol. The Mostagi et al. [14], used as a measurement tool a kinematic analysis measuring the hip joint angle, and the study results indicated that general exercise was superior compared to a Pilates programme, on increasing subjects' flexibility. The Natour et al. [18], evaluated the flexibility using the sit and reach test, but there was no statistically significant improvement between the experimental group and the control group. The Valenza et al. [19], used the ''finger to floor'' test for the flexibility assessment, and the study results showed that was a statistically significant improvement in flexibility in favor of the experimental group. Furthermore, they used the single-limb stance test in order to evaluate the participants' balance, and the study results indicated also, statistically significant difference between the two groups for balance, favoring the experimental group.

Additionally, the Cruz-Díaz et al. [15] used as measurement tools the FES-I for the evaluation of the FoF, and the TUG test for the balance assessment. Concerning the study results, only the Pilates group indicated a significant reduction in FoF and improvement in balance, after six weeks of intervention. Lopes et al. (2017) evaluated also, the participants' balance with the use of the SEBT. The research results showed that there was an immediate statistically significant improvement in the Pilates group regarding the dynamic balance, in comparison to the control group. Finally, the Natour et al. [18] and the Kofotolis et al. [21], examined the Qol as an outcome in their studies, and they used the SF-36 as a measurement tool for the participants' evaluation. The results in one study indicated that there were statistically significant difference favoring the experimental group regarding some Qol domains, and on the other study, that both Pilates program and trunk strength exercises improved HRQOL, however, a greater statistically difference for the Pilates group compared to the trunk strengthening exercise group was observed.

## DISCUSSION

The purpose of this systematic review was to explore the effects of Pilates on CLBP or NSCLBP, with or without other interventions compared to no treatment or other treatments. There have been a number of previous research on this topic, however, current systematic reviews have revealed that the data from these studies is inconsistent [23, 24, 10]. According to the literature review that was performed, 8 from the 10 studies [15,16,18,19,20,17,22,21] indicated that a Pilates exercise programme is effective in the management of pain in patients with NSCLBP or CLBP. These scientific evidence about pain reduction, agreed also, with the study of the Patti et al. [24], who executed a 14-week program of Pilates exercises and observed a significantly improvement in pain. However, Mostagi et al. [14] did not found any difference in pain levels of the study's subjects after the Pilates-based intervention. Similarly, the Amaral et al. [6], in a more recent study, disagreed about the

effectiveness of Pilates method in the pain management in patients suffering from CLBP. In addition, in the studies of the Cruz-Díaz et al. [15] and the Cruz-Díaz et al. [16], the Pilates programme was implemented in conjunction with a physical therapy protocol, and on the study of the Natour et al. [18], in conjunction with use of NSAID respectively.

Equally, 8 from the 10 included studies, agreed that a Pilates rehabilitation programme significantly improves the functionality/disability on patients with CLBP [14, 15, 16, 18, 21,19, 22, 17]. Furthermore, a previous study of the Miyamoto et al. [25], who examined a six-week modified Pilates programme compare to a minimal intervention, had shown that there was an improvement on subjects' disability after the intervention, however, these effects were not sustained over time. In addition, the Lopes et al. [20] and the Amaral et al. [6], did not report a relevant positive treatment outcome in functionality/disability after the implementation of the Pilates exercise programme.

Moreover, 2 of the 3 studies that examined the effectiveness of Pilates on flexibility, reported that there was a significant improvement on study's participants with NSCLBP [14,6]. However, the Natour et al. (2015), did not find any relevant difference between the two study groups. Furthermore, all three studies that examined the balance as a treatment outcome, following a Pilates programme, concluded that there was a significant improvement in patients' balance [15, 19, 20]. In an earlier study of the Lee et al. [26] who had implemented an 8-week treatment protocol, had also observed significant improvement of patients' balance with mat Pilates exercise. Similarly, the two studies that included as an outcome the patient's Qol, agreed that the Pilates method improves significantly the Qol in patients with NSCLBP [21,18].

Furthermore, there were 3 studies that compare the effectiveness of Pilates-based exercise to other forms of physical exercise in subjects with NSCLBP. The Mostagi et al. [14] indicated that there were no differences between the Pilates and general exercises groups with regard to pain and functionality, however, for the improvement of functionality and flexibility, general exercises seemed to be superior to Pilates method. On the other hand, the Kofotolis et al. [21] found that both Pilates programme and trunk strength exercises are effective for the treatment outcomes that were measured, however, the Pilates-based exercises were a bit superior, compared to the trunk strengthening exercises. Equally, the Mazloum et al. [22] found that selective Pilates exercises were superior to extension-based exercises in terms of pain and physical disability. Additionally, in a previous high quality RCT of the Marshall et al. [27] who compared the effectiveness of Pilates exercises to stationary cycling in patients with CLBP, had been reported statistically significant improvements in pain and functional ability, but not in other high quality RCTs. However, improvements in pain and functional abilities with Pilates exercise compared to other kinds of exercise have not been reported as statistically significant in prior systematic reviews [23].

## Limitations

There are certain limitations to this systematic review that should be carefully considered. Initially, in this systematic review were included only English RCTs, and this results in language bias. None of the two studies that were omitted because of its language seemed to be possibly relevant RCTs when titles and abstracts were translated into English. Furthermore, the screening of the RCTs was conducted only by one reviewer in order to be resolved possible discrepancies for the inclusion and exclusion criteria and for the quality of evidence of the included RCTs, and not with the assistance of other independent reviewers. Additionally, the advanced RCTs search for the systematic review was performed only in one database, PubMed, and as a consequence, the relevant article

results regarding the topic, were quite limited. Moreover, the keywords and terms were used in the search, which were relevant to the intervention were only the ‘‘Pilates’’, ‘‘Clinical Pilates’’ and ‘‘Pilates method’’, and did not used alternative keywords to describe the Pilates method, such as ‘‘core strength’’ and ‘‘core stability’’. Thus, the related articles to Pilates that use these terms were not included in the systematic review, and the results of this study were further limited. Another weakness of the systematic review, is that it is focused on pain, functional abilities, flexibility, balance and Qol in patients with CLBP or NSCLBP. Other outcomes, such as kinesiophobia and lumbar mobility/ROM, could have been clinically significant to be examined.

Regarding the limitations of the studies included in the systematic review, the availability and diversity of the source of evidence, influenced the review's results' strength. The results were less definite due to the small number of RCTs that compared Pilates exercise to other forms of exercise. The precision of findings was also hampered by small sample sizes in most of the included RCTs and limited follow-up in several RCTs. In addition, some RCTs did not have a control group, in one RCT the participants did use of NSAIDS concurrently with the intervention, and one RCT also, examined only the immediate effect of the Pilates method and not after several sessions with a comprehensive treatment protocol like the other researches did. Moreover, the study population in some RCTs was young with minimal disability and pain, and in some others, was older than 65 years, and thus restricting the generalizability of the findings. Finally, only one of the 10 studies included in the systematic review satisfied the item related to blinding of therapists (criterion no 6), and the blinding of individuals (criterion no 5), was missing from all the studies, which is a very significant limitation, because blinding is a methodological component of RCTs that helps to reduce bias and increase the validity of the results [27].

## CONCLUSION

In conclusion, the aim of this systematic review was to explore the effectiveness of Pilates exercise programmes in adults with CLBP or NSCLBP, regarding pain, functionality, balance, flexibility and Qol outcomes. A detailed advanced literature search was performed in a scientific database for recent English RCTs, and the methodological quality of all the studies were included in this systematic review, were assessed using the PEDro scale. The systematic review’s findings were that a Pilates exercise programme as a rehabilitation in patients with CLBP or NSCLBP, compared to no other intervention, results in statistically significant improvements in pain and functional abilities in the short term. It appears also, to have beneficial outcomes in terms of balance, flexibility, and quality of life, nevertheless, the evidence supporting this claim is limited, as well as, the data concerning the effectiveness of the Pilates method compared to other form of physical exercise. This systematic review presents an update on the effectiveness of Pilates exercise in patients with CLBP, which can be utilized to help clinicians make more informed decisions. Through the evaluation of the achieved results, researchers will be able to learn more about how these benefits are maintained over time, allowing them to prevent relapses and to develop an appropriate treatment plan for CLBP patients.

### *Declaration by Authors*

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## REFERENCES

1. Allegri M, Montella S, Salici F, et al.: Mechanisms of low back pain: a guide

for diagnosis and therapy. F1000Research. 2016, 5:10. 10.12688/f1000research.8105.2
2. Kwok B.C, Lim J. X. L, Kong P W, et al.: The Theoretical Framework of the Clinical Pilates Exercise Method in Managing Non-Specific Chronic Low Back Pain: A Narrative Review. Biology. 2021, 10:1096. 10.3390/biology10111096
3. Manchikanti L, Singh V, Falco F J E, et al.: Epidemiology of Low Back Pain in Adults. Neuromodulation. 2014, 17:3-10. 10.1111/ner.12018
4. Urits I, Burshtein A, Sharma M, et al.: Low Back Pain, a Comprehensive Review: Pathophysiology, Diagnosis, and Treatment. Curr Pain Headache Rep. 2019, 23:10.1007/s11916-019-0757-1
5. Qaseem A, Wilt T J, McLean R M, et al.: Noninvasive Treatments for Acute, Subacute, and Chronic Low Back Pain: A Clinical Practice Guideline from the American College of Physicians. Ann. Intern. Med. 2017, 166:514-10. 10.7326/M16-2367
6. Amaral D D V, Miyamoto G C, Franco K F M, et al.: Examination of a Subgroup of Patients with Chronic Low Back Pain Likely to Benefit More From Pilates-Based Exercises Compared to an Educational Booklet. J Orthop Sports Phys Ther. 2019, 50:1-32. 10.2519/jospt.2019.8839
7. Balagué F, Mannion A F, Pellisé F, et al.: Non-specific low back pain. Lancet. 2012, 379:482-491. 10.1016/s0140-6736(11)60610-7
8. Izzo R, Popolizio T, D'Aprile P, et al.: Spinal pain. Eur. J. Radiol. 2015, 84:746-56. 10.1016/j.ejrad.2015.01.018
9. Patti A, Bianco A, Paoli A, et al.: Effects of Pilates Exercise Programs in People With Chronic Low Back Pain. Medicine. 2015, 94:383. 10.1097/md.0000000000000383
10. Yamato T P, Maher C G, Saragiotto B T, et al.: Pilates for low back pain. CDSR. 2015, 10.1002/14651858.CD010265.pub2
11. Stoop R, Clijsen R, Leoni D, et al.: Evolution of the methodological quality of controlled clinical trials for myofascial trigger point treatments for the period 1978-2015: A systematic review. Musculoskelet. Sci. Pract. 2017, 30:1-9. 10.1016/j.msksp.2017.04.009
12. Moseley A M, Herbert R D, Sherrington C, et al.: Evidence for physiotherapy practice: A survey of the Physiotherapy Evidence Database (PEDro). Aust J Physiother. 2002, 48:43-49. 10.1016/S0004-9514(14)60281-6
13. Kamonseki D H, Christenson P, Rezvanifar S C, et al.: Effects of Manual Therapy on Fear Avoidance, Kinesiophobia and Pain Catastrophizing in Individuals with Chronic Musculoskeletal Pain: Systematic Review and Meta-Analysis. Musculoskelet. Sci. Pract. 2020, 51:102311. 10.1016/j.msksp.2020.102311
14. Mostagi F C, Dias J M, Pereira L M, et al.: Pilates versus general exercise effectiveness on pain and functionality in non-specific chronic low back pain subjects. J Bodyw Mov Ther. 2014, 19:636-645. 10.1016/j.jbmt.2014.11.009
15. Cruz-Díaz D, Martínez-Amat A, De la Torre-Cruz M J, et al.: Effects of a six-week Pilates intervention on balance and fear of falling in women aged over 65 with chronic low-back pain: A randomized controlled trial. Maturitas. 2015, 82:371-376. 10.1016/j.maturitas.2015.07.022
16. Cruz-Díaz D, Martínez-Amat A, Osuna-Pérez M C, et al.: Short- and long-term effects of a six-week clinical Pilates program in addition to physical therapy on postmenopausal women with chronic low back pain: a randomized controlled trial. Disabil. 2015, 38:1300-1308. 10.3109/09638288.2015.1090485
17. Cruz-Díaz D, Romeu M, Velasco-González C, et al.: The effectiveness of 12 weeks of Pilates intervention on disability, pain and kinesiophobia in patients with chronic low back pain: a randomized controlled trial. Clin. Rehabil. 2018, 32:1249-1257. 10.1177/0269215518768393
18. Natour J, Cazotti L D A, Ribeiro L H, et al.: Pilates improves pain, function and quality of life in patients with chronic low back pain: a randomized controlled trial. Clin. Rehabil. 2015, 29:59-68. 10.1177/0269215514538981
19. Valenza M, Rodriguez-Torres J, Cabrera-Martos I, et al.: Results of a Pilates exercise program in patients with chronic non-specific low back pain: A randomized controlled trial. Clin. Rehabil. 2016, 31:753-760. 10.1177/0269215516651978
20. Lopes S, Correia C, Félix G, et al.: Immediate effects of Pilates based therapeutic exercise on Postural Control of young individuals with non-specific low back pain: a randomized controlled trial.

Complement Ther Med. 2017, 34:104-110. 10.1016/j.ctim.2017.08.006
21. Kofotolis N, Kellis E, Vlachopoulos S P, et al.: Effects of Pilates and trunk strengthening exercises on health-related quality of life in women with chronic low back pain. J Back Musculoskelet Rehabil. 2016, 29:649-659. 10.3233/bmr-160665
22. Mazloum V, Sahebozamani M, Barati A, et al.: Randomized clinical trial The effects of selective Pilates versus extension-based exercises on rehabilitation of low back pain. J Bodyw Mov Ther. 2017, 22:999-1003. 10.1016/j.jbmt.2017.09.012
23. Wells C, Kolt G S, Marshall P, et al.: The Effectiveness of Pilates Exercise in People with Chronic Low Back Pain: A Systematic Review. PLoS One. 2014, 1:9. 10.1371/journal.pone.0100402
24. Wong C M, Rugg B, Geere J A: The effects of Pilates exercise in comparison to other forms of exercise on pain and disability in individuals with chronic non-specific low back pain: A systematic review with meta-analysis. Musculoskelet. Care. 2023, 21:78-96. 10.1002/msc.1667
25. Miyamoto G C, Costa L O P, Galvanin T, et al.: Efficacy of the Addition of Modified Pilates Exercises to a Minimal Intervention in Patients with Chronic Low Back Pain: A Randomized Controlled Trial. Phys. Ther. 2013, 93:310-320. 10.2522/ptj.20120190
26. Lee C, Hyun J, & Kim S G: Influence of Pilates Mat and Apparatus Exercises on Pain and Balance of Businesswomen with Chronic Low Back Pain. J. Phys. Ther. Sci. 2014, 26:475-477. 10.1589/jpts.26.475
27. Karanicolas P J, Farrokhyar F, Bhandari M: Blinding: Who, what, when, why, how?. Can. J. Surg. 2010, 5:345-348.

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