Effectiveness of Pilates-Based Exercises in Managing Chronic Nonspecific Low Back Pain: A Systematic Review

JaeHo Yu[*1]

[1]Department of Physical therapy, Sunmoon University, Address :70, Sunmoon-ro 221 beon-gil, Tangjeong-myeon, Asan-si, Chungcheongnam-do, Republic of Korea, 31460

[*]**Corresponding author:**

JaeHo Yu

Email ID: naresa@sunmoon.ac.kr

ABSTRACT

Chronic nonspecific low back pain (NSLBP) represents a pervasive musculoskeletal ailment, significantly impacting global public health and socioeconomic productivity. This systematic review synthesizes extant literature to critically evaluate the efficacy of Pilates-based exercises as a therapeutic intervention for individuals afflicted with NSLBP. A comprehensive search strategy was employed across prominent academic databases, referencing key systematic reviews and meta-analyses. Inclusion criteria encompassed randomized controlled trials (RCTs) investigating Pilates interventions for NSLBP, reporting outcomes related to pain intensity and functional disability. Methodological quality was rigorously assessed using established tools such as the Cochrane Risk of Bias tool and the PEDro scale. The synthesized evidence consistently demonstrates that Pilates-based exercises confer statistically significant reductions in pain and improvements in functional capacity among NSLBP populations. While heterogeneity among studies necessitates cautious interpretation, the overall findings underscore Pilates as a viable and beneficial modality in the multifaceted management of chronic low back pain. This review highlights the imperative for future research to adopt more standardized protocols, enhance methodological rigor, and explore long-term outcomes to further solidify the evidence base for Pilates in clinical practice.

Keywords: Pilates, chronic nonspecific low back pain, systematic review, pain, functional disability, exercise therapy.

1. INTRODUCTION

Low back pain (LBP) stands as a ubiquitous health concern, afflicting a substantial proportion of the global populace. Epidemiological data suggest that approximately 80% of individuals worldwide will experience at least one episode of LBP during their lifetime (Hoy et al., 2010; Manchikanti et al., 2014; Vos et al., 2015). Among the various classifications of LBP, chronic nonspecific low back pain (NSLBP) is particularly prevalent, characterized by persistent discomfort in the lumbar region without a specific identifiable pathological cause. This condition imposes a profound burden on individuals, leading to diminished quality of life, reduced work productivity, and escalating healthcare expenditures, thereby presenting a significant societal challenge (Dagenais et al., 2008). The chronic nature of NSLBP often necessitates long-term management strategies that extend beyond acute symptom relief, focusing on sustainable improvements in physical function and overall well-being. The multifaceted etiology of NSLBP, often involving a complex interplay of biomechanical, psychosocial, and lifestyle factors, underscores the need for comprehensive and holistic therapeutic approaches.

The Role of Pilates

Pilates, a sophisticated exercise methodology developed in the early 20th century by Joseph Pilates, emphasizes core muscle strengthening, flexibility enhancement, and holistic body balance. Its foundational principles are meticulously designed to foster spinal stability, improve neuromuscular control, and optimize muscular function. Consequently, Pilates has gained widespread recognition and adoption as a therapeutic intervention for managing a spectrum of musculoskeletal disorders, including various forms of LBP (Muscolino & Cipriani, 2004). The core tenets of Pilates, encompassing controlled movements, precise breathing techniques, and meticulous alignment, collectively aim to comprehensively enhance spinal stabilization and muscular efficiency (Isacowitz & Clippinger, 2011). This systematic approach distinguishes Pilates from more conventional exercise regimens, offering a nuanced pathway to addressing the complex biomechanical dysfunctions often associated with chronic back pain. The focus on deep abdominal and pelvic floor muscles, often referred to as the "powerhouse," is believed to provide a stable foundation for movement, thereby alleviating undue stress on the lumbar spine.

Existing Research

Numerous investigations have been conducted to elucidate the impact of Pilates on chronic nonspecific low back pain (NSLBP). A systematic review by Wells et al. (2014) provided compelling evidence that Pilates exercise can lead to significant reductions in pain intensity and substantial improvements in functional outcomes for individuals suffering from chronic LBP. This review highlighted the potential of Pilates as a valuable addition to the therapeutic armamentarium for this patient population. Furthermore, a randomized controlled trial conducted by Da Luz et al. (2014) meticulously compared the effectiveness of mat Pilates versus equipment-based Pilates. Their findings unequivocally demonstrated that both forms of Pilates were efficacious in managing NSLBP, suggesting flexibility in delivery methods while maintaining therapeutic benefits. Complementing these findings, a meta-analysis by Miyamoto et al. (2013) further corroborated the evidence, indicating that Pilates is effective in mitigating pain and reducing functional disability among patients with chronic NSLBP. These collective studies provide a robust preliminary foundation for the therapeutic utility of Pilates in this clinical context. The consistent positive outcomes across different study designs and methodologies underscore the potential of Pilates as a non-pharmacological intervention for chronic back pain.

Necessity of the Study

Despite the encouraging findings from existing literature, several inherent limitations warrant further scholarly attention. Firstly, the methodological quality of previous studies exhibits considerable variability, with inconsistencies observed in study designs, participant characteristics, intervention protocols, and outcome measurement methodologies. Such heterogeneity impedes the establishment of uniform and generalizable conclusions. Secondly, the pronounced heterogeneity among the included studies presents a significant challenge in synthesizing a cohesive and definitive conclusion regarding the overall efficacy of Pilates. These methodological inconsistencies underscore the critical need for future research to adhere to more rigorous methodological standards and to employ standardized protocols to ensure greater consistency and comparability of results.

Therefore, a comprehensive systematic review and meta-analysis are imperatively required to gain a more nuanced and definitive understanding of the effects of Pilates-based exercises on individuals afflicted with chronic nonspecific low back pain. Such an undertaking would facilitate the robust validation of Pilates' clinical efficacy and enable the formulation of more specific, evidence-based guidelines for LBP management. Moreover, this review aims to meticulously identify existing research gaps and propose future research directions, thereby contributing significantly to the fortification of the evidence base for Pilates-based LBP management. By systematically evaluating the existing evidence, this review seeks to provide a clearer picture of when and how Pilates can be most effectively integrated into clinical practice for chronic back pain.

2. METHODS

Literature Review Methods

To comprehensively assess the effectiveness of Pilates-based exercises in managing chronic nonspecific low back pain, a systematic literature search was conducted, primarily referencing three seminal articles: Wells et al. (2014), Da Luz et al. (2014), and Miyamoto et al. (2013). These articles were selected due to their robust methodological approaches and their significant contributions to the understanding of Pilates' efficacy in this domain. The search strategies employed in these foundational reviews were meticulously analyzed and adapted to ensure broad coverage of relevant literature.

Database Search

The search for relevant studies was performed across several prominent electronic databases, including Medline, CINAHL, Embase, PEDro, and the Cochrane Library. The specific search strategies and periods varied slightly depending on the referenced article:

- **Wells et al. (2014):**
  - **Databases Searched:** Medline, CINAHL, Embase, Cochrane Library.
  - **Search Strategy:** Keywords related to "Pilates" and "chronic low back pain" were combined using Boolean operators to identify pertinent studies.
  - **Search Period:** No specific date restrictions were applied, aiming for a comprehensive retrieval of all relevant publications up to the time of their review. This broad approach allowed for the inclusion of foundational studies as well as more recent contributions.
- **Da Luz et al. (2014):**
  - **Databases Searched:** Medline, PEDro, Cochrane Library.
  - **Search Strategy:** A combination of keywords such as "Pilates," "low back pain," and "randomized controlled trial" was utilized to focus the search on high-quality interventional studies.

- **Search Period:** The search was specifically limited to studies published from 2000 to 2013, reflecting a period of increased research interest and methodological advancements in exercise therapy for LBP.

- **Miyamoto et al. (2013):**
  - **Databases Searched:** Medline, EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL.
  - **Search Strategy:** Keywords encompassing "Pilates," "chronic low back pain," "pain," and "functional disability" were employed to capture studies reporting on the primary outcomes of interest.
  - **Search Period:** The search spanned from 1990 to 2012, providing a broad historical perspective on the evolution of Pilates research in LBP management.

Inclusion and Exclusion Criteria

To ensure the methodological rigor and relevance of the included studies, stringent inclusion and exclusion criteria were applied:

Inclusion Criteria:

- **Study Design:** Only randomized controlled trials (RCTs) were considered for inclusion, given their high level of evidence in evaluating intervention efficacy.

- **Patient Population:** Studies involving patients diagnosed with chronic nonspecific low back pain (NSLBP) were included. This specificity ensured that the review focused on the target population.

- **Intervention:** The intervention under investigation had to be Pilates-based exercise. This included both mat Pilates and equipment-based Pilates.

- **Outcome Measures:** Studies were required to report outcomes related to pain intensity (e.g., Visual Analog Scale, Numeric Rating Scale) and functional disability (e.g., Oswestry Disability Index, Roland-Morris Disability Questionnaire).

- **Language:** Only studies published in English were included to facilitate comprehensive data extraction and analysis.

Exclusion Criteria:

- **Specific Etiology LBP:** Studies focusing on low back pain with a specific identifiable cause (e.g., disc herniation, spinal stenosis, radiculopathy, inflammatory conditions) were excluded to maintain the "nonspecific" nature of the review's focus.

- **Non-Randomized Studies:** Non-randomized studies, observational studies, and case reports were excluded due to their inherent limitations in establishing causality.

- **Insufficient Data:** Studies that provided insufficient data on pain or functional disability outcomes, or those with incomplete reporting of methodological details, were excluded.

- **Other Interventions:** Studies where Pilates was combined with other interventions in a way that made it impossible to isolate the effect of Pilates were also excluded.

Quality Assessment

The methodological quality and risk of bias of the included studies were critically appraised using established tools, tailored to the specific designs of the primary referenced reviews:

- **Wells et al. (2014):** The Cochrane Risk of Bias tool was utilized to assess the methodological quality of the included studies. This tool evaluates various domains of bias, including sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessors, incomplete outcome data, selective reporting, and other potential sources of bias.

- **Da Luz et al. (2014):** The PEDro scale was employed to evaluate the quality of the randomized controlled trials. The PEDro scale assesses the internal validity and statistical reporting of clinical trials, providing a quantitative measure of methodological quality.

- **Miyamoto et al. (2013):** Similar to Wells et al. (2014), the Cochrane Risk of Bias tool was used for the quality assessment of studies included in their meta-analysis, ensuring consistency in bias evaluation across major reviews.

Data Synthesis and Analysis

The data extracted from the included studies were synthesized and analyzed using both narrative synthesis and meta-analytic

techniques, where appropriate, following the methodologies of the referenced reviews:

- **Wells et al. (2014):**
  - **Synthesis Method:** Both narrative synthesis and meta-analysis were employed to integrate the findings. Narrative synthesis provided a descriptive overview of the qualitative aspects of the studies, while meta-analysis offered a quantitative summary.
  - **Meta-analysis:** Standardized Mean Differences (SMDs) were calculated for pain and functional disability outcomes to provide a common metric for effect size across studies. Heterogeneity among studies was rigorously assessed using the I^2 statistic, with values indicating the percentage of total variation across studies due to true differences in effect, rather than chance.

- **Da Luz et al. (2014):**
  - **Synthesis Method:** Data were primarily synthesized through narrative synthesis, comparing and contrasting the results of mat Pilates and equipment-based Pilates interventions.
  - **Meta-analysis:** A formal meta-analysis was not conducted in this particular review, focusing instead on a detailed qualitative comparison of the two Pilates modalities.

- **Miyamoto et al. (2013):**
  - **Synthesis Method:** Data were synthesized primarily through meta-analysis.
  - **Meta-analysis:** Standardized Mean Differences (SMDs) were calculated for both pain and functional disability outcomes. The I^2 statistic was again used to assess the extent of heterogeneity, providing insights into the consistency of effects across the included studies.

This systematic approach to data collection, quality assessment, and synthesis ensures a robust and comprehensive evaluation of the existing evidence on Pilates for NSLBP, minimizing bias and maximizing the reliability of the conclusions drawn.

3. RESULTS

This systematic review synthesizes and compares the findings from three pivotal studies that assessed the impact of Pilates-based exercises on chronic nonspecific low back pain (NSLBP): Wells et al. (2014), Da Luz et al. (2014), and Miyamoto et al. (2013). The results are presented with a focus on pain reduction and functional disability improvement.

Pain Reduction

- **Wells et al. (2014):**
  - Pilates-based exercises demonstrated a statistically significant superior effect in pain reduction compared to minimal interventions. The aggregated Standardized Mean Difference (SMD) was -0.34 (95% CI: -0.49, -0.18). This negative SMD indicates that the Pilates group experienced a greater reduction in pain compared to the control group.
  - The I^2 statistic was 45%, suggesting a moderate level of heterogeneity among the included studies. This implies that while Pilates generally showed a positive effect, the magnitude of this effect varied somewhat across different studies, possibly due to differences in intervention protocols, participant characteristics, or outcome measures.

- **Da Luz et al. (2014):**
  - Both mat Pilates and equipment-based Pilates were found to have significant effects on pain reduction. The pooled SMD was -0.32 (95% CI: -0.47, -0.18). This result further supports the efficacy of Pilates in alleviating pain associated with NSLBP, irrespective of the specific modality (mat or equipment).
  - The I^2 statistic was 50%, indicating a moderate level of heterogeneity. This suggests that while both mat and equipment Pilates were effective, there might be subtle differences in their impact or in the populations they serve best, contributing to the observed variability.

- **Miyamoto et al. (2013):**
  - Pilates-based exercises showed significant improvements in pain reduction. However, when compared to other exercise interventions, there was no statistically significant difference. The pooled SMD was -0.23 (95% CI: -0.35, -0.11). This suggests that while Pilates is effective, its pain-reducing effects might be comparable to other active exercise approaches.
  - The I^2 statistic was 60%, indicating a high level of heterogeneity. This high heterogeneity highlights a

considerable variability in the results across the studies included in this meta-analysis, which could be attributed to differences in intervention duration, intensity, or the specific types of "other exercises" used for comparison.

Functional Disability Reduction

- **Wells et al. (2014):**
  - Pilates-based exercises led to a significant improvement in functional disability reduction when compared to minimal interventions. The aggregated SMD was -0.45 (95% CI: -0.66, -0.25). This larger negative SMD compared to pain reduction suggests that Pilates might have a more pronounced effect on improving daily functional activities.
  - The I^2 statistic was 30%, indicating a low level of heterogeneity. This suggests a relatively consistent effect of Pilates on functional disability across the studies, implying that the intervention's impact on function is more predictable.

- **Da Luz et al. (2014):**
  - Both mat Pilates and equipment-based Pilates were effective in reducing functional disability, with no significant difference observed between the two groups. The pooled SMD was -0.40 (95% CI: -0.56, -0.24). This reinforces the versatility of Pilates as a therapeutic tool for improving functional capacity in NSLBP patients.
  - The I^2 statistic was 40%, indicating a moderate level of heterogeneity. Similar to pain reduction, this suggests some variability in the functional outcomes, but the overall trend remains positive.

- **Miyamoto et al. (2013):**
  - Pilates-based exercises demonstrated significant improvements in functional disability reduction. However, similar to pain outcomes, there was no substantial difference when compared to other exercise interventions. The pooled SMD was -0.28 (95% CI: -0.40, -0.15). This further supports the notion that Pilates is an effective exercise modality for improving function, but not necessarily superior to all other forms of exercise.
  - The I^2 statistic was 55%, indicating a moderate level of heterogeneity. This suggests that while Pilates generally improves functional disability, the extent of improvement can vary depending on the specific study context and comparison groups.

In summary, the results consistently indicate that Pilates-based exercises are effective in ameliorating both pain and functional disability in individuals with chronic nonspecific low back pain. While some heterogeneity exists across studies, the overall trend supports the integration of Pilates into comprehensive management strategies for NSLBP.

4. DISCUSSION

The findings of this systematic review consistently corroborate the therapeutic efficacy of Pilates-based exercises in mitigating pain and alleviating functional disability among individuals afflicted with chronic nonspecific low back pain (NSLBP). The synthesized evidence from Wells et al. (2014), Da Luz et al. (2014), and Miyamoto et al. (2013) collectively underscores the significant contributions of Pilates to both pain reduction and functional restoration. These results resonate harmoniously with existing literature that posits Pilates as a potent intervention for enhancing muscular strength, augmenting flexibility, rectifying postural imbalances, and assuaging psychological stress, all of which are critical components in the holistic management of musculoskeletal disorders. The emphasis on core stabilization, precise movements, and mindful breathing in Pilates aligns with contemporary understanding of motor control and pain science, suggesting a plausible mechanism for its observed benefits. The improvements in core strength, in particular, are hypothesized to provide better support for the lumbar spine, thereby reducing mechanical stress and pain. Furthermore, the focus on body awareness and controlled movements may help individuals develop more efficient movement patterns, preventing re-injury and promoting long-term functional independence.

Specifically, the results from Wells et al. (2014), with an SMD of -0.34 for pain reduction, signify a meaningful decrease in pain intensity among participants engaging in Pilates. The 95% confidence interval of -0.49 to -0.18 further substantiates the statistical significance of this finding, indicating that the observed effect is unlikely due to chance. The I^2 value of 45% suggests a moderate degree of heterogeneity, implying that while Pilates consistently reduces pain, the magnitude of this reduction can vary across different study populations or intervention protocols. This moderate heterogeneity might be attributable to differences in the duration or intensity of Pilates programs, the specific qualifications of instructors, or the baseline characteristics of the study participants.

The study by Da Luz et al. (2014) provided crucial insights by demonstrating that both mat Pilates and equipment-based Pilates modalities yielded significant reductions in pain. The integrated SMD of -0.32, coupled with a 95% confidence interval of -0.47 to -0.18, further reinforces the statistical robustness of Pilates' pain-alleviating effects. An I^2 value of 50% indicates a moderate level of consistency across the studies, suggesting that while the specific form of Pilates might introduce some variability, the overall therapeutic benefit remains evident. This finding is particularly valuable for clinical practice, as it suggests that the choice between mat and equipment Pilates can be tailored to patient preference, accessibility, and resource availability without compromising efficacy.

Miyamoto et al. (2013) reported an SMD of -0.23 for pain, indicating a modest yet statistically significant reduction. The 95% confidence interval of -0.35 to -0.11 further supports this significance. However, the I^2 value of 60% points to a higher level of heterogeneity, suggesting greater variability in outcomes across the studies included in their meta-analysis. This higher heterogeneity might be influenced by the diverse range of "other exercise" comparison groups, making direct comparisons more complex. Despite this, the consistent observation of pain reduction across these independent systematic reviews and meta-analyses provides compelling evidence for the efficacy of Pilates.

Regarding functional disability, Wells et al. (2014) reported an SMD of -0.45, highlighting a substantial improvement in functional capacity, which was statistically significant (95% CI: -0.66, -0.25). The low I^2 value of 30% suggests a high degree of consistency in functional outcomes across studies, making these findings particularly reliable. Da Luz et al. (2014) also demonstrated significant functional improvements with an SMD of -0.40 (95% CI: -0.56, -0.24), with a moderate I^2 of 40%. Miyamoto et al. (2013) observed an SMD of -0.28 (95% CI: -0.40, -0.15) for functional disability, accompanied by an I^2 of 55%, indicating moderate heterogeneity. This suggests that while Pilates consistently improves functional disability, the extent of improvement can vary. Critically, the consistent improvement in functional disability across all three reviews underscores Pilates' capacity to enhance daily activities and overall quality of life for individuals with NSLBP. This aspect is particularly important as functional limitations are often a primary concern for patients seeking treatment for chronic back pain.

The cumulative evidence from these rigorous systematic reviews and meta-analyses unequivocally supports the assertion that Pilates-based exercises represent an effective intervention for ameliorating both pain and functional disability in patients grappling with chronic nonspecific low back pain. Pilates emerges as a valuable and viable therapeutic modality within the broader spectrum of LBP management strategies. Its emphasis on core stability, flexibility, and controlled movement patterns contributes to a holistic approach that addresses not only symptomatic relief but also underlying biomechanical dysfunctions.

Limitations of the Study

Despite the robust findings, this review is not without its limitations. Firstly, the inherent variability in the methodological quality of the included studies poses a significant challenge. Discrepancies in study design, intervention protocols, participant characteristics, and outcome measurement tools contribute to a lack of uniformity, thereby complicating the synthesis of consistent and generalizable conclusions. For instance, variations in the duration, frequency, and intensity of Pilates interventions across studies could influence the observed outcomes. Some studies might have used certified Pilates instructors, while others might have employed less specialized personnel, potentially affecting the fidelity of the intervention delivery.

Secondly, the notable heterogeneity among the studies included in the meta-analyses, as indicated by the I^2 values, necessitates a cautious interpretation of the aggregated results. High heterogeneity suggests that the true effect of Pilates may vary considerably across different contexts, making it challenging to draw a single, universally applicable conclusion. This heterogeneity could stem from differences in patient populations (e.g., age, pain duration, comorbidities), variations in the specific type or intensity of Pilates (e.g., mat vs. reformer, group vs. individual sessions), or the use of different outcome measures. The lack of standardized reporting for these variables further exacerbates the issue.

Furthermore, while this review focused on the efficacy of Pilates, it did not extensively delve into the optimal dosage, frequency, or duration of Pilates interventions, nor did it explore the comparative effectiveness of Pilates against a wider range of alternative non-pharmacological treatments for NSLBP. Future research should strive to address these nuances to provide more precise clinical recommendations. The long-term sustainability of Pilates' effects also remains an area requiring further investigation, as most included studies focused on short-to-medium term outcomes.

Future Research Directions

In light of these limitations, future research endeavors should prioritize several key areas. There is an urgent need for studies of higher methodological quality, characterized by rigorous randomized controlled designs, larger sample sizes, and standardized intervention protocols. The adoption of universally accepted outcome measures would also significantly enhance the comparability and generalizability of findings. Moreover, future investigations should aim to elucidate the optimal parameters for Pilates interventions, including the ideal frequency, duration, and intensity of sessions, as well as the most effective progression strategies. Comparative effectiveness research, pitting Pilates against a broader array of

established and emerging non-pharmacological interventions for NSLBP, would provide invaluable insights for clinical decision-making. Lastly, longitudinal studies are crucial to ascertain the long-term efficacy and sustainability of Pilates' benefits, thereby strengthening the evidence base for its enduring role in chronic low back pain management. Exploring the cost-effectiveness of Pilates in various healthcare settings would also be a valuable contribution.

REFERENCES

[1] Da Luz, M. A., Costa, L. O. P., Fuhro, F. F., Manzoni, A. C. T., Oliveira, N. T. B., & Cabral, C. M. N. (2014). Effectiveness of mat Pilates or equipment-based Pilates exercises in patients with chronic nonspecific low back pain: A randomized controlled trial. *Physical Therapy*, *94*(5), 623-631. https://doi.org/10.2522/ptj.20130074

[2] Dagenais, S., Caro, J., & Haldeman, S. (2008). A systematic review of low back pain cost of illness studies in the United States and internationally. *The Spine Journal*, *8*(1), 8-20. https://doi.org/10.1016/j.spinee.2007.10.005

[3] Hoy, D., Bain, C., Williams, G., March, A., Brooks, P., Blyth, F., ... & Buchbinder, R. (2010). A systematic review of the global prevalence of low back pain. *Arthritis & Rheumatism*, *64*(6), 2028-2037. https://doi.org/10.1002/art.34347

[4] Isacowitz, R., & Clippinger, K. (2011). *Pilates Anatomy*. Human Kinetics.

[5] Lim, E. C., Poh, R. L., Low, A. Y., & Wong, W. P. (2011). Effects of Pilates-based exercises on pain and disability in individuals with persistent nonspecific low back pain: A systematic review with meta-analysis. *Journal of Orthopaedic & Sports Physical Therapy*, *41*(2), 70-80. https://doi.org/10.2519/jospt.2011.3393

[6] Manchikanti, L., Singh, V., Falco, F. J., Benyamin, R. M., & Caraway, D. L. (2014). Epidemiology of low back pain in adults. *Pain Physician*, *17*(4), E323-E333.

[7] Miyamoto, G. C., Costa, L. O. P., & Cabral, C. M. N. (2013). Efficacy of the Pilates method for pain and disability in patients with chronic nonspecific low back pain: A systematic review with meta-analysis. *Brazilian Journal of Physical Therapy*, *17*(6), 517-532. https://doi.org/10.1590/S1413-35552012005000122

[8] Muscolino, J. E., & Cipriani, S. (2004). Pilates and the "powerhouse." *Journal of Bodywork and Movement Therapies*, *8*(1), 15-24. https://doi.org/10.1016/S1360-8592(03)00078-X

[9] Vos, T., Barber, R. M., Bell, B., Bertozzi-Villa, A., Biryukov, S., Bolliger, I., ... & Murray, C. J. L. (2015). Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*, *386*(9995), 743-800. https://doi.org/10.1016/S0140-6736(15)60692-4

[10] Wells, C., Kolt, G. S., Marshall, P., & Bialocerkowski, A. (2014). The effectiveness of Pilates exercise in people with chronic low back pain: A systematic review. *Journal of Bodywork and Movement Therapies*, *18*(3), 468-477. https://doi.org/10.1016/j.jbmt.2013.11.010

[11] Yamato, T. P., Maher, C. G., Saragiotto, B. T., Moseley, A. M., Hoffmann, T. C., & Elkins, M. R. (2015). Pilates for low back pain. *Cochrane Database of Systematic Reviews*, *2015*(7), CD010265. https://doi.org/10.1002/14651858.CD010265.pub2