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Meta-Analysis

Meta-Analysis the Effects of Stretching and Whole Body Vibration Exercise in Reducing Low Back Pain among Heavy Equipment Operator Workers

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ABSTRACT

Background: Low back pain is pain due to disc pressure on the nerves that come out through the gap between the vertebrae. Heavy equipment operators have a high risk of developing LBP due to prolonged sitting and vibrations from the machine. This will result in injury and also stiffness in the joints and spine. This study aims to analyze the effect of stretching and whole-body vibration exercise on reducing low back pain in heavy equipment operators/workers.
Subjects and Method: This is a meta-analytical study and a systematic review. The articles used were obtained from several electronic databases including Google Scholar, PubMed, Springer Link, Clinical key and ProQuest. The articles used in this study are articles that have been published from 2011-2021. The keywords used in the search were “stretching and low back pain”, “stretching and whole body vibration exercise”, “stretching and low back pain, “stretching or whole body vibration exercise or low back pain”, “stretching or whole body vibration exercise". The article under study is a full text article with a Randomized Controlled Trial (RCT) design, a measure of the relationship used with Mean SD. Articles were collected using the PRISMA diagram, and analyzed using the Review Manager 5.4 . application.
Results: Stretching (SMD -0.47; 95% CI=-0.96 to 0.02; p=0.06) and Whole Body Vibration Exercise (SMD -0.37; 95% CI= -0.72 to -0.02; p=0.04) has an effect on reducing Low Back Pain.
Conclusion: Stretching exercises and Whole Body Vibration can reduce and decrease lower back pain after getting the intervention.

Keywords: stretching, low back pain, whole body vibration exercise

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BACKGROUND

Occupational health and safety (K3) problems in general have not received serious attention. According to the latest estimates released by the International Labor Organization (ILO), 2.78 million workers die each year due to occupational accidents and occupational diseases. Approximately 2.4 million (86.3 percent) of these mortality were due to occupational diseases (Hamalainen et al., 2017). According to ILO estimation, more than 1.8

million work-related deaths occur in each year in the Asia and Pacific region. In fact, two thirds of work-related deaths in the world occur in Asia (ILO, 2018). In addition, there are around 374 million non-fatal work-related injuries and illnesses each year, which results in a lot of work absenteeism (Primasari and Denny, 2016).

Occupational disease (PAK) is any disease caused by work or work environment. Diseases that arise due to work relationships are diseases caused by work or the work environment. Many factors influence the occurrence of work-related diseases, such as work that is not ergonomic. Work that is not ergonomic can trigger musculoskeletal complaints. These factors include overstretching, repetitive activities, and unnatural work attitudes. In addition, pressure and vibration are also the cause of musculoskeletal complaints (Deswita, 2014).

One of the musculoskeletal diseases that can be caused by the wrong work attitude is low back pain (LBP). Low Back Pain was identified as one of the top three occupational health and safety problems by the American regional World Health Organization (WHO) in 2001 (Afia and Dwita, 2018). Low Back Pain (LBP) is one of the most common types of Musculoskeletal disorders found in occupational diseases. LBP is very often encountered in everyday life, especially in industrialized countries. In the United States, LBP is one of the most common complaints after headache (Goodman et al., 2013).

The World Health Organization (WHO) also stated that in industrialized countries, 2%-5% experience LBP in each year. Furthermore, the National Safety Council reported that work-related illness with the highest frequency of occurrence was pain or pain in the lower back, which was 22% of 1.7 million cases. United States statistics show an incidence rate of 15% - 20% per year. There are 90% of cases of back pain which are not caused by organic disorders, but by errors in body position at work. Back pain causes more time lost than a strike of 20 million work days because of it (Muheri, 2010).

One of the employments that are at risk for the emergence of occupational diseases and health problems in the form of complaints of low back pain are heavy equipment operators, this is because the vibrations received by heavy equipment operators are influenced by the vehicle engine, road surface, vehicle speed, suspension system (Hadyan, 2015). Research conducted by Asriadi et al. (2011) at one of the mining companies shows that most of the incidence of low back pain afflicts employees who work as operators of heavy equipment and factory machinery, as many as 87 people (46.3%). This is very possible considering the exposure to the causes of low back pain is very large in employees in this type of work. The activity of heavy equipment and factory machine operators in working is mostly in a sitting position. Meanwhile, heavy equipment or vehicles that are operated can cause vibrations throughout the body so that it is very possible for the workers to experience complaints of low back pain. Therefore, a long-term work with a continuous work pattern will increase the risk of complaints becoming greater.

Heavy equipment operators have a high risk of developing LBP due to prolonged sitting and vibrations from the machine. In addition, the condition of the narrow steering cabin does not allow the driver to move his limbs freely, so that a long-term work with static sitting conditions and limited mobility, it will result in injury, stiffness in the joints and spine. Exposure to vibration during work can

trigger low back pain. Low back pain is low back pain due to irritation of the inter-vertebral disc or disc pressure on the nerves that exit through the gap between the vertebrae. Whole body vibration is mechanical energy that is transferred to the body as a whole usually through a support system such as a seat. Heavy equipment operators spend time working on the runway with demands for high work productivity so they cannot leave the heavy equipment before the predetermined break time in order to get optimal results (Putri, 2020).

One of the non-pharmacological pain management used in reducing pain is stretching exercises. Doing stretching movements slowly can help to overcome pain (Pamungkas, 2010). LBP can be prevented and reduced by doing regular stretching. This can happen because stretching exercises are able to maintain physical fitness by increasing circulation in the muscle blood so that spasms and ischemia are reduced so that the metabolism of substances needed by the body is well distributed and processes the disposal of the remnants of substances that are not needed by the body more effectively. Stretching can also make muscles, ligaments, tendons and joints more flexible so that the movements performed during activities are more optimal and the stress on the muscles can also be reduced, making work easier, reducing anxiety and depression, reducing the risk of injury and making the body gets better (Satrio, 2017).

According to research conducted by Afia and Dwita (2018), giving stretching to workers who experience low back pain (LBP) can increase muscle relaxation, by stretching, the muscles of the body that experience spasms can become more relaxed and comfortable. The incidence of LBP in workers is usually caused by work activities carried out in one position and occur continuously, positions that are not ergonomic and work that exceeds their abilities (heavy equipment workers). This is in line with Okananto (2014) which showed that the method of giving stretching treatment can reduce the level of complaints of low back pain significantly in the treatment group. Research conducted by Bolarinde et al. (2017) on mining workers who experience low back pain also shows that stretching exercises affect significant pain reduction in individuals with low back pain.

In addition to giving stretching to patients with low back pain, whole body vibration exercise is a popular method to reduce pain intensity and improve function and quality of life. Vibration stimulation with exercise intervention can complement standard physical rehabilitation programs for LBP (Wang et al., 2016). Wang et al (2019) showed that whole body vibration exercise can provide more benefits than general exercise to relieve pain and improve functional disability in patients with non-specific chronic low back pain. Dong et al. (2020) stated that whole body vibration to exercise can increase the activation of the lumbar-abdominal muscles in patients with chronic low back pain (CLBP).

Various studies have been carried out to see the effect of stretching and whole-body vibration exercise on reducing low back pain, but the results of the research still do not show consistent results. Further analysis is needed to reach a convincing conclusion. Therefore, researchers are interested in examining the effect of stretching and whole-body vibration exercise. Researchers used a systematic review approach to relevant studies by conducting a meta-analysis to identify clearly the effect of stretching and whole-body vibration exercise on reducing low back pain in heavy equipment workers.

SUBJECTS AND METHOD

1. Study Design

This is a quantitative study with a meta-analysis study design. Meta-analysis is an analysis of several studies using a systematic review approach and statistical techniques to identify, assess and combine the results of relevant studies in order to reach a stronger conclusion (Stroup et al., 2000). The merger is intended to reduce the bias of study conducted separately.

2. Inclusion Criteria

This study has inclusion criteria, including: Articles must be full papers in English, articles using a Randomized Controlled Trial (RCT) study design, appropriate titles, containing the variables to be studied, articles from 2010-2021, the interventions provided were: have stretching and whole-body vibration exercise, the study subjects were operators aged 20-55 years old.

3. Exclusion Criteria

The exclusion criteria in this study including: Articles published other than English.

4. Operational Definition

The formulation of the problem was carried out by considering the eligibility criteria defined using PICO, namely, Population: heavy equipment operator workers, Intervention: stretching and whole-body vibration exercise, Comparison: no stretching and no whole body vibration exercise and Outcome: decreased low back pain.

Stretching is a simple physical activity that aims to overcome muscle tension and stiffness so that the body feels better.

Whole body vibration exercise is an intervention method to reduce pain intensity and improve function and quality of life by not moving or performing dynamic exercises via a vibration platform.

Low back pain is an injury in the form of pain felt in the spinal column (lower back), muscles, nerves, tendons, joints, or cartilage caused by errors in work.

5. Instrument of the Study

The instrument in this study used the Visual Analog Scale (VAS) as a stretch measurement tool, the Oswestry Disability Index (ODI) as a whole-body vibration exercise measurement tool and the Back Pain Functional Scale (BPFS) as a low back pain measurement tool.

6. Data Analysis

Data analysis was performed using Software Review Manager (RevMan) 5.3 issued by the Cochrane Collaboration. RevMan was used to calculate the overall OR or RR, describing the 95% Confidence Interval (CI) using the effects model, as well as the heterogeneity of the data (I^2). The results of data analysis were in the form of the effect size score of the heterogeneity of the study which the results of the data that had been analyzed were interpreted in the form of forest plots and funnel plots.

RESULTS

Research from primary studies related to the effect of post isometric relaxation and whoe body vibration exercise on reducing low back pain contained 15 articles. Articles were obtained from 3 continents, namely 4 studies from the Asian continent, 6 from the European continent and 5 studies from the Americas. The outcome for some articles was that there was a decrease in pain levels after being given a stretching intervention and whole-body vibration exercise.

The article search was carried out using a database based on the PRISMA flow diagram, which can be seen in Figure 1. The study quality assessment was carried out qualitatively and quantitatively. Assessment of research quality using the Critical Appraisal Skills Program (CASP) can be seen in Table 1. Each of the 11 questions

was answered with the answer choices: Yes, No and Unclear. After assessing the quality of the study, a total of 16 articles included in the quantitative synthesis process of the meta-analysis were analyzed using RevMan 5.3.

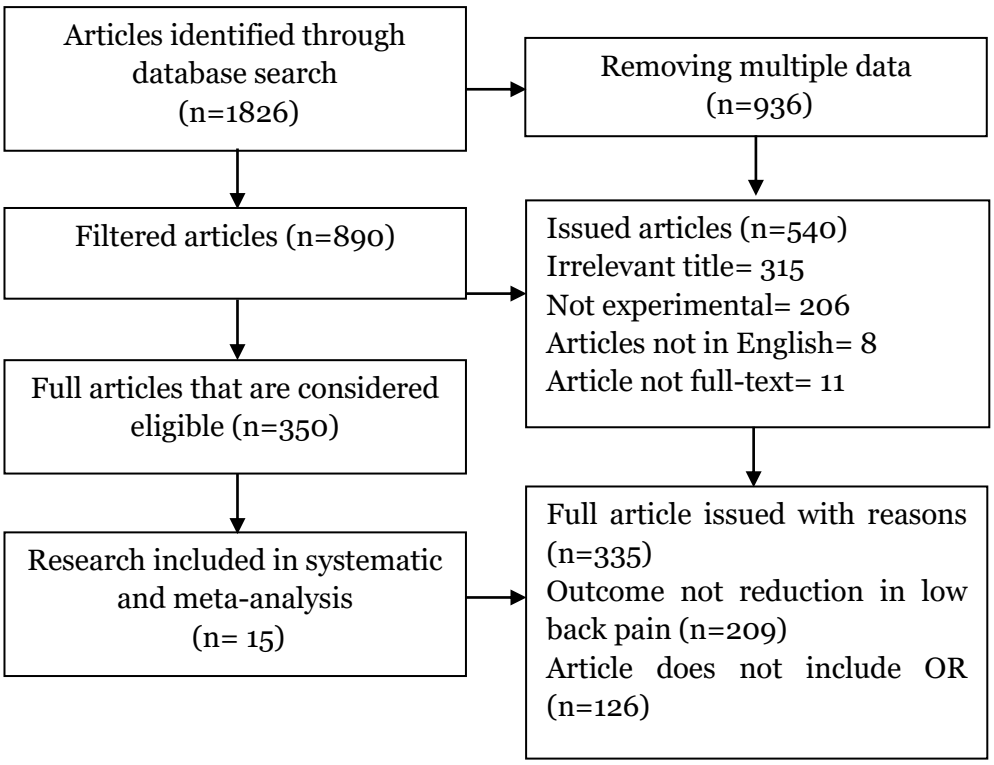

Figure 1. PRISMA flow diagram

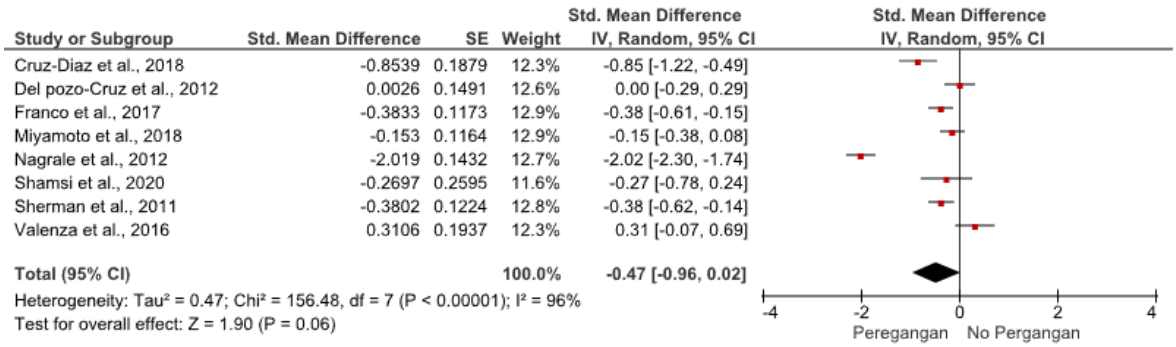

Figure 2. Forest plot of stretching on low back pain reduction

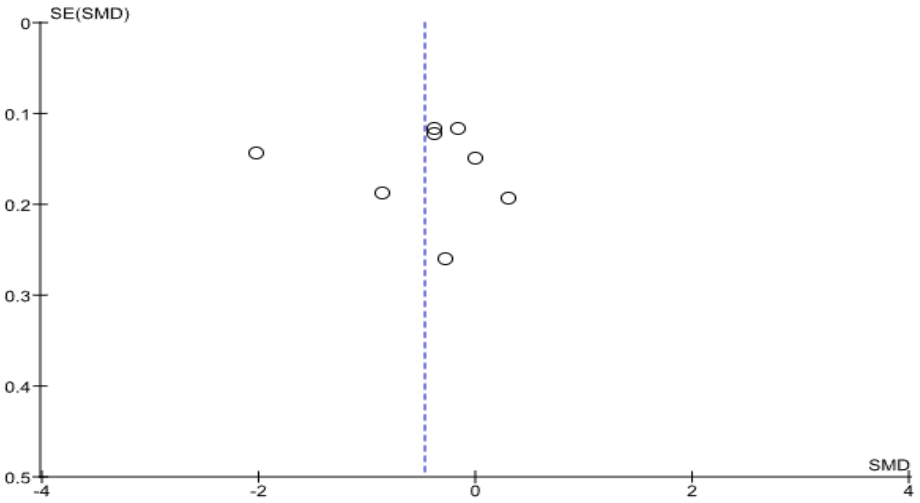

Figure 3. Funnel plot of stretching on low back pain reduction

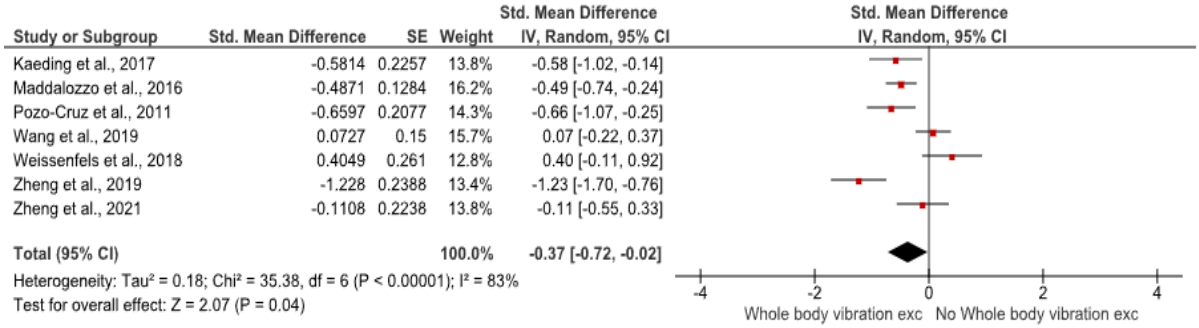

Figure 4. Forest plot of whole-body vibration exercise on low back pain reduction

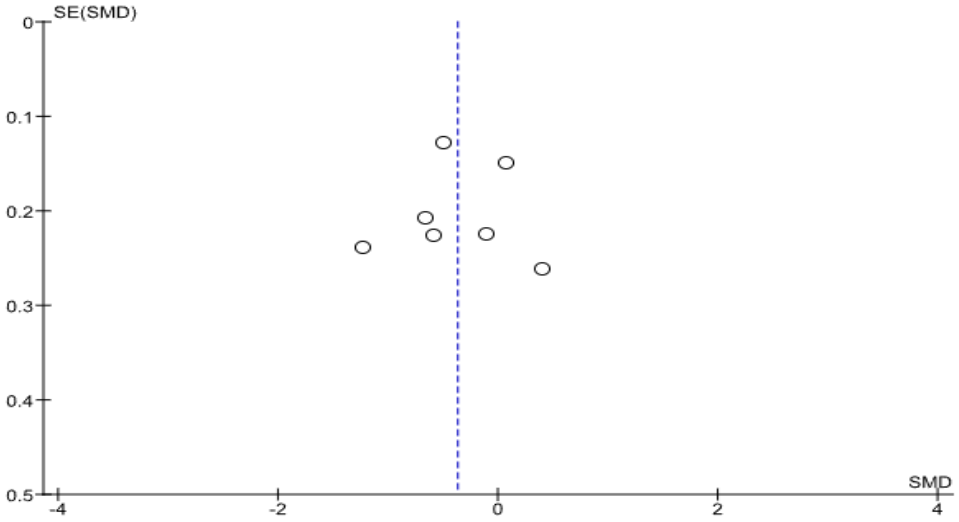

Figure 5. Funnel plot of whole-body vibration exercise on low back pain reduction

Table 1. Assessment of study quality

Publication	1	2	3	4	5	6	7	8	9	10	11
Shamsi et al. (2020)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pozo-Cruz et al. (2012)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Cruz-Diaz et al. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear
Sherman et al. (2011)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Unclear
Valenza et al. (2016)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nagrale et al. (2012)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Miyamoto et al. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Franco et al. (2017)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Wang et al. (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear
Pozo-Cruz et al. (2011)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maddalozzo et al. (2016)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Unclear
Zheng et al. (2019)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Kaeding et al. (2017)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weissenfels et al. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear
Zheng et al. (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

1. The effect of stretching on the reduction of low back pain

a. Forest plot of the effect of stretching on the reduction of low back pain

Interpretation of the results of the meta-analysis process can be seen through the forest plot. Figure 2 shows that heavy equipment operators who were given intervention in the form of stretching could reduce low back pain compared to those who did not receive intervention. From the results of data processing, it can be seen that there is high heterogeneity between experiments (I^2=96%; p<0.001). Stretching can reduce low back pain by -0.47 units higher compared to other interventions or no intervention at all, but it was not statistically significant (SMD= -0.470; 95% CI= -0.960 to 0.020; p=0.060).

b. Funnel Plot of the effect of stretching on the reduction of low back pain

A funnel plot is a plot that represents the approximate size of the effect of each study on its estimated accuracy, which is usually the standard error. Based on Figure 2, the funnel plot of stretching to decrease low back pain showed that there was a publication bias which was indicated by the asymmetry of the right and left plots.

2. The effect of whole body vibration exercise on the reduction of low back pain

a. Forest Plot of whole body vibration exercise on the reduction of low back pain

Interpretation of the results of the meta-analysis process can be seen through the forest plot. Figure 4 shows that heavy equipment operators who were given an intervention in the form of whole-body vibration exercise could reduce low back pain compared to those who did not receive intervention. Meanwhile, there was high heterogeneity between experiments (I^2=83%; p=0.001). Giving whole body vibration exercise can reduce low back pain by -0.370 units higher compared to other interventions or no intervention at all, statistically significant (SMD -0.370; 95% CI= -0.720 to -0.020; p=0.040).

b. Funnel plot of whole body vibration exercise on the reduction of low back pain

Figure 5 of funnel plot regarding whole body vibration exercise on reducing low back pain showed that there was no publication bias which was indicated by the symmetry of the right and left plots.

DISCUSSION

This systematic study and meta-analysis raised the theme of the effect of whole-body vibration and stretching on reducing low back pain. The independent variables analyzed were whole body vibration and stretching. The number of relevant studies that discuss the effect of whole-body vibration and stretching on reducing low back pain that are published and accessible are still few and have data excess problems (data duplication) (Murti, 2018). Most of the reported statistical results are in percent or crude odd ratio (cOR), which the study did not control for confounding factors.

The combined estimation of the relationship between each stretching and whole-body vibration exercise with reduced low back pain was processed using the RevMan 5.4 application with the generic inverse-variance method. This method is used to analyze data in the form of rate, time-to-event, hazard ratio, ordinal scale, adjusted estimate, average difference or average ratio.

The results of the systematic study and meta-analysis are presented in the form of forest plots and funnel plots. The

forest plot shows visually the magnitude of variation (heterogeneity) (Akobeng, 2005 in Murti, 2018). The funnel plot shows the relationship between the study effect size and the sample size of the various studies studied which can be measured in different ways (Murti, 2018). The funnel plot can be seen by the asymmetry of the study, which is looking at the number of points on the right and left sides compared to the standard error and the balance of the number of studies on the right and left sides (D'Souza et al., 2002). The results of the forest plot in this study showed that heavy equipment operators who were given an intervention in the form of stretching could reduce low back pain by -0.470 units higher compared to those who did not receive intervention.

Low Back Pain can be prevented and reduced by stretching regularly. This can happen because stretching exercises are able to maintain physical fitness by increasing circulation in the muscle blood so that spasms and ischemia are reduced so that the metabolism of substances needed by the body is well distributed and processes the disposal of the remnants of substances that are not needed by the body more effectively. Stretching can also make muscles, ligaments, tendons and joints more flexible so that the movements performed during activities are more optimal and the stress on the muscles can also be reduced, making work easier, reducing anxiety and depression, reducing the risk of injury and making the body gets better (Afia, 2018),

Pozo-Cruz et al. (2012) stated that the intervention group that was given regular exercise that included muscle strengthening, mobility and stretching that focused on postural muscle stability showed clinical improvements in quality of life and was effective in treating low back pain compared to control group that did not receive the intervention. The findings of research conducted by Bolarinde (2017) also show that stretching exercises, lumbar stabilization exercises, and back care are effective in reducing pain and functional disability in individuals with work-related low back pain, however, stretching exercises are more effective than lumbar stabilization exercises and back care for pain relief and function improvement.

Stretching aims to restore and repair the muscles into their original shape, so that they can restore the form of posture in a normal position. Pilates exercise is a type of low impact exercise that uses stretching and strengthening methods aimed at increasing the endurance, strength, and flexibility of the pelvic, abdominal, and vertebral muscles for spinal stabilization either in a stationary or moving position (Kloubec, 2010). Research conducted by Cruz-Diaz et al (2018) showed that pilates intervention was effective in patients with chronic non-specific low back pain in the management of disability, pain and kinesiophobia (fear of pain due to movement).

This is in line with Valenza et al. (2016) which stated that an 8-week pilates exercise program is effective in overcoming disability, reducing pain, and increasing flexibility and balance in patients with chronic non-specific low back pain. The Pilates method can reduce pain and improve function for people with chronic low back pain. Miyamoto et al. (2018) revealed that adding two sessions of Pilates exercises can lead to better results in managing pain and disability for patients with non-specific chronic low back pain and doing Pilates three times a week is the preferred option.

Sherman et al. (2019) also found that physical activity that involves stretching, such as yoga or more conventional exercises, has considerable benefit in indivi-

duals with moderate levels of low back pain. Most of the benefits of yoga stem from the physical benefits of stretching and strengthening muscles rather than its mental component in improving function and reducing symptoms from chronic low back pain. Although the specific exercises differ, most of the yoga and stretching classes are spent doing exercises designed to stretch and strengthen the back and leg muscles.

The results of the forest plot showed that heavy equipment workers who were given an intervention in the form of whole-body vibration exercise could reduce low back pain by -0.37 units higher compared to those who did not receive intervention.

Most clinical practitioners recommend exercise intervention as an efficient solution to improve back function and reduce pain in patients with low back pain. Whole body vibration exercise (WBV) is a popular method for reducing pain intensity and improving function and quality of life. WBV workouts are dynamic exercises via a vibration platform. Vibration stimulation can complement standard physical rehabilitation programs for LBP (Zheng et al., 2018). Whole body vibration exercise (WBV), a non-invasive intervention, has become an increasingly popular treatment for low back pain. To investigate whether the proprioceptive performance and pain control of patients with non-specific low back pain can be proven by whole body vibration exercise (Zheng et al., 2019).

Wang et al. (2019) showed that the whole-body vibration exercise program had a significant positive effect in terms of relieving pain, reducing functional disability, and improving quality of life in non-specific chronic low back pain compared to the control group. In addition, no serious side effects were observed in the intervention group from the beginning to the end of the 12-week intervention period. Patients with non-specific chronic low back pain felt the effects of finding changes in back pain symptoms after the whole-body vibration exercise intervention. These results indicate an increase in the visual analogue scale and Oswestry Disability Index scores consistent with the perceived effect. These findings suggest that whole body vibration exercise may have a more beneficial effect than general exercise for patients with non-specific chronic low back pain.

Research conducted by Pozo-Cruz et al. (2011) also shows that whole body vibration exercise for 12 weeks is feasible and may be a new physical therapy for patients with non-specific low back pain. In addition, the whole-body vibration exercise program is an appropriate and safe form of therapy for patients with non-specific chronic low back pain (NCLBP). In line with this study, Zheng et al. (2019) also stated that lumbar flexion and extension proprioception as measured by joint position significantly increased and pain was significantly reduced after 12 weeks of whole-body vibration exercise in NSLBP patients.

Weissenfells et al. (2018) stated that whole-body vibration is an effective exercise method to reduce chronic nonspecific LBP and maximize trunk strength in people with these complaints. The study needs to be expanded to include comparisons with active groups (whole body vibration and conventional back reinforcement).

According to Kaeding et al. (2017), whole body vibration exercise is an effective, safe, and suitable intervention for work while sitting in workers with chronic low back pain. Previous studies have shown that the application of WBV exercises with sinusoidal vibrations for patients with LBP and CLBP is safe and can effectively reduce pain and increase functional capacity, as

well as reduce disability, due to LBP and health-related quality of life. However, until this day, these interventions have not been used as workplace-based sports activities for workers with CLBP (Pozo-Cruz et al., 2011).

AUTHORS CONTRIBUTION

Melinda Febianca Gaurinindi is the main researcher who selected the topic, searched and collected the data. Eti Poncorini Pamungkasari and Bhisma Murti analyzed the data and reviewed the documents.

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This study used personal fund from the main researcher.

CONFLICT OF INTEREST

There was no conflict of interest in this study.

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REFERENCES

Bolarinde SO, Babatunde SA, Adegoke B, Ayanniyi O (2017). Effects of stretching exercises on pain and functional disability in quarry workers with work-related low back pain. Saf Health Work. 9: 2. doi: 10.1017/S014-67236(11)402378-7.

Dong Y, Huifang W, Yan Z, Chen B, Zheng Y, Liu X, Qiao J, et al. (2020). Effects of whole body vibration exercise on lumbar-abdominal muscles activetion for patients with chronic low back pain. Res Article BMC Sports Science Med Rehabil. 08(45): 34. doi: 10.11-86/s13102-020-00226-4.

Franco KM, Franco YDS, Oliveira NBD, Miyamoto GC, Santos MO, Liebano RE, Cabral CN (2016). Is interferential current prior to Pilates exercises more effective than placebo in patients with chronic non-specific low back pain? A randomized controlled trial. Arch Phys Med Rehabil. 98(2):320-328. doi: 10.1016/j.apmr.-2016.08.485.

Goodman DM, Burke AE, Livingston EH (2013). JAMA patient page. Low back pain. JAMA. 309(16):1738. doi: 10.1-001/jama.2013.3046.

Hamalainen P, Takala J, Boon KT (2017). Perkiraan global kecelakaan kerja dan penyakit yang berhubungan dengan kerja. Kongres Dunia XXI tentang keselamatan dan kesehatan di tempat kerja (Global Estimates of Occupational Accidents and Work-Related Diseases. XXI World Congress on Occupational Safety and Health). Singapura: Lembaga Keselamatan dan Kesehatan Kerja.

Kaeding TS, Karch A, Schwarz R, Flor T, Wittke T-C, Kück M, Böselt G, Tegtbur U, Stein L (2017). Whole-body vibration training as a workplace-based sports activity for employees with chronic low-back pain. Scand J Med Sci Sports. 27(12): 2027-2039. doi: 10.1111/sms.12852.

Miyamoto GC, Franco KFM, Dongen JMV, Franco YRDS, Oliveira NTBD, Amaral DDV, Branco ANC, et al. (2018). Different doses of Pilates-based exercise therapy for chronic low back pain: a randomised controlled trial with economic evaluation. Br J Sports Med. (13):859-868. doi: 10.11-36/bjsports-2017-098825.

Nagrale AV, Patil SP, Gandhi RA, Learman K (2012). Effect of slump stretching versus lumbar mobilization with exercise in subjects with non-radicular low back pain: a randomized

clinical trial. J Man Manip Ther. 20 (1): 35-42. doi: 10.1179/204261861-1Y.0000000015.

Pozo-Cruz BD, Gusi N, Pozo-Cruz JD, Adsuar JC, Hernandez-Mocholí M, Parraca JA (2012). Clinical effects of a nine-month web-based intervention in subacute non-specific low back pain patients: a randomized controlled trial. J Rehabil Med. 27(1):28-39. doi: 10.1177/0269215512444632.

Pozo-Cruz BD, Mocholí MAH, Adsuar JC, Parraca JA, Muro I, Gusi N (2011). Effects of whole-body vibration therapy on main outcome measures for chronic non-specific low back pain: a single-blind randomized controlled trial. J Rehabil Med. 43(8):689-94. doi: 10.2340/16501977-0830.

Shamsi M B, Mirzaei M, Shahsavari S, Safari A, Saeb M (2020). Modeling the effect of static stretching and strengthening exercise in lengthened position on balance in low back pain subject with shortened hamstring: a randomized controlled clinical trial. BMC. Musculoskelet Disord. 7(3): 794-809. doi: 10.1186/s12891-020-03823-z.

Sherman KJ, Cherkin DC, Wellman RD, Cook AJ, Hawkes RJ, Delaney K, Deyo RA (2011). A randomized trial comparing yoga, stretching, and a self-care book for chronic low back pain. Arch Intern Med. 171(22): 2019-2026. doi: 10.1001/archinternmed.-2011.524.

Valenza MC, Rodríguez-Torres J, Cabrera-Martos I, Díaz-Pelegrina A, Aguilar-Ferrándiz ME, Castellote-Caballero Y (2016). Results of a Pilates exercise program in patients with chronic non-specific low back pain: A randomized controlled trial. Clin Rehabil. 31(6): 753-760. doi: 10.1177/026921-5516651978.

Wang P, Yang L, Liu C, Wei X, Yang X, Zhou Y, Jiang H, et al. (2016). Effects of whole body vibration exercise associated with quadriceps resistance exercise on functioning and quality of life in patients with knee osteoarthritis: a randomized controlled trial. Clin Rehabil. 30(11): 1074-1087. doi: 10.1177/0269215515607970.

Weissenfels A, Teschler M, Willert S, Hettchen M, Fröhlich M, Kleinöder H, Kohl M, et al. (2018). Effects of whole-body electromyo stimulation on chronic nonspecific low back pain in adults: a randomized controlled study. J Pain Res. 20(11): 1949-1957. doi: 10.2147/JPR.S164904.

Zheng Y-L, Wang X-F, Chen B-L, Gu W, Wang X, Xu B, Zhang J, et al. (2019). Effect of 12-week whole-body vibration exercise on lumbopelvic proprioception and pain control in young adults with nonspecific low back pain. Med Sci Monit. 25(3): 443-452. doi: 10.12659/MSM.912047.