INTRODUCTION

Low back pain is a common problem experienced by people of all age groups that causes disability and affects quality of life. More than eighty percent of the working age group experience complaints of low back pain during their lifetime. The causes of low back pain are often associated with the application of poor posture in the workplace, activities such as lifting heavy loads, performing repetitive movements that can traumatize the lower back area. Other factors that can worsen the intensity of low back pain include age, gender, hypertension, smoking, ergonomics, lack of job satisfaction, excess weight, lack of physical activity and depression.1

Low back pain conditions can affect patient activity, participation and mobilization. Research conducted by Lamoth et al., 2006 and Al-Obaidi et al., 2003 described significant differences in walking speed between healthy subjects and patients with chronic low back pain. Comparison of walking speed in healthy subjects is 1.3 (±0.2) meters/second while subjects with low back pain is 0.92 (±0.3) meters/second. A decrease in walking speed will affect the maximum oxygen consumption capacity (VO2 max) of subjects with low back pain, thus affecting functional capacity ability.1,3

Lack of physical activity is associated with decreased fitness and muscular capacity such as maximal muscle volume and strength. VO2 max drops gradually by about 0.3-0.4 %/day during physical inactivity. Decreases in VO2 max and muscle volume are evident after two weeks of rest, with decreases of 7-15% (0.5-1.1%/day) and 6-8% (0.4-0.6%/day), respectively. This decline in physical fitness is accompanied by reduced muscle contractile function as assessed by decreased muscle volume and strength.4

Vitamin D is an important vitamin in the musculoskeletal system which is a group of fat-soluble secosteroids and has receptors identified in muscle tissue.5 Vitamin D plays a role in bone homeostasis, and most studies suggest there is an association of vitamin D deficiency with chronic pain syndromes such as chronic low back pain. Several case series and observational studies suggest that vitamin D deficiency may be a source of impaired nociceptive and neuromuscular function in patients with chronic pain.6

Management of chronic LBP is handled by administering pharmacological and

Effect of Aerobic Walking on Maximal Oxygen Consumption and Serum Vitamin D Levels in Patients with Mechanical Chronic Low Back Pain in Office Workers at Dr. Soetomo Hospital Surabaya

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ABSTRACT

Background: Sedentary behavior is a common risk factor for mechanical chronic low back pain. Functional capacity and serum vitamin D levels are associated with low back pain intensity. The aim to analyze the effect of aerobic exercise walking on maximal oxygen consumption and serum vitamin D levels in patients with mechanical chronic low back pain.

Method: true experimental with pre and post-test randomized control group design. Each group consisted of 16 respondents. The treatment group received additional aerobic exercise walking 3x/week, intensity 40-50% HRR (weeks 1-3), 50-60% HRR (weeks 4-6) and 60-80% HRR (weeks 7-8), 30 minutes per session for 8 weeks. The control group only received conventional training 3x/week for 8 weeks. The parameters evaluated were VO2 max and 25(OH)D. Measurements were taken before and after 8 weeks of intervention.

Results: The VO2 max values of both groups increased with a significant difference after the intervention (p < 0.001) and there was a difference in the difference (p < 0.001). 25(OH)D levels in both groups increased with no significant difference after the intervention (p = 0.720) and no significant difference in the difference after the intervention (p = 0.662).

Conclusion: There is a difference in the addition of walking aerobic exercise to conventional exercise compared to conventional exercise alone on maximal oxygen consumption, but there is no difference on serum vitamin D levels in mechanical chronic low back pain patients.

Keywords: 25(OH)D, aerobic exercise walking, chronic low back pain, max VO2, vitamin D.

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non-pharmacological therapy. Non-pharmacological therapy can be given through strengthening, flexibility, and aerobic exercises.\(^7\)\(^8\) Compliance with training is an important consideration in choosing the right exercise to manage chronic low back pain. Walking aerobic exercise is the simplest, safest exercise and can be done by all age groups. Walking exercises have local and systemic effects on chronic mechanical low back pain patients.\(^9\) The local impact is activating the lumbar muscles, characterized by isometric contractions during the walking phase to prevent muscle atrophy in the lumbar area. Systemic effects during the walking phase cause an increase in body temperature which can lead to a decrease in adipocyte tissue deposition in skeletal muscles. The purpose of this study was to analyze the effect of aerobic walking training on maximal oxygen consumption and serum vitamin D levels in patients with mechanical chronic low back pain in office workers with sedentary behavior.

**METHODS**

This research is a true experimental study with a pre and post-test randomized control group design. This study was approved by the Health Research Ethics Commission at Dr. Soetomo General Hospital Surabaya with ethical feasibility number: 0993/LOE/301.4.2/VIII/2022. Initial and final data collection took place at the Outpatient Clinic of the Medical Rehabilitation Installation at Dr. Soetomo General Hospital Surabaya. The study subjects consisted of 32 chronic LBP patients who worked as office workers at Dr. Soetomo General Hospital Surabaya, which were divided into treatment and control groups (each consisting of 16 subjects). The treatment group received additional aerobic walking exercise with a frequency of 3 times a week, intensity of 40-50% HRR in the first week to the third week, 50-60% HRR in the fourth week to the sixth week and 60-80% HRR in the seventh week to the eighth week, duration of 30 minutes and conventional exercise therapy 3x/week for 8 weeks. The control group only received exercise therapy 3x/week for 8 weeks. The parameters evaluated in this study were VO\(_{2}\) max and 25(OH)D. Measurements were taken twice, before and after 8 weeks of intervention.

Inclusion criteria included: 1) Men and women aged 18 to 55 years; 2) Fully employed as an office worker at Dr. Soetomo General Hospital Surabaya and occupying a job position for at least a year; 3) Having daily physical activity that is classified as light based on the IPAQ SF assessment; 4) Diagnosis of non-organic mechanical chronic low back pain ≥ 3 months to ≤ 1 year without signs of red flags; 5) Willing to participate in the study by signing informed consent. Exclusion criteria include: 1) Patients who actively perform physical exercise activities more than walking activities There are chronic diseases such as hypertension, ischemic heart disease, diabetes mellitus, kidney disease, restrictive and obstructive airway diseases; 2) There are neuromusculoskeletal and vascular disorders in the lower limbs that are contraindicated for walking training; 3) There is a fracture and or history of surgery on the backbone or lower limbs in less than six months; 4) Patients receiving treatment for cancer or suffering from low back pain due to injury; 5) Pregnant for female subjects; 6) Impaired vision, hearing and balance function; 7) BMI ≥ 30 kg/m\(^2\); 8) Low back pain intensity with NPRS ≥ 7; 9) Fever; 10) Received vitamin D supplementation before; 11) Not willing to participate in the study.

Data analysis was performed with the help of the Statistical Program for Social Sciences (SPSS) version 26 program including descriptive analysis, normality test, homogeneity test, parametric statistical test (paired t-test) and calculation of effect size with Cohen’s d. The p value is considered meaningful if p < 0.05.

**RESULTS**

The general characteristics of the study subjects are shown in Table 1.

The VO\(_{2}\) max and 25(OH)D values between the treatment groups before and after the addition of the walking aerobic exercise program to conventional exercise, and in the control group before and after conventional exercise are shown in Table 2.

The VO\(_{2}\) max and 25(OH)D values between the treatment groups after the addition of the walking aerobic exercise program to conventional exercise, and in the control group after conventional exercise are shown in Table 3.

The difference (delta) in VO\(_{2}\) max and 25(OH)D values between groups after 8 weeks of exercise is shown in Table 4.

### Table 1. Test of normality and homogeneity of the characteristics of the study subjects in both groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Treatment (n = 16) Means ± SD</th>
<th>p-value (Normality)</th>
<th>Control (n = 16) Means ± SD</th>
<th>p-value (Normality)</th>
<th>p-value (Homogeneity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>38.50 ± 11.35</td>
<td>0.195</td>
<td>37.09 ± 12.06</td>
<td>0.093</td>
<td>0.566</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>0.093</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male = 8 (50%)</td>
<td></td>
<td>Female = 8 (50%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.50 ± 8.12</td>
<td>0.129</td>
<td>162.13 ± 9.35</td>
<td>0.208</td>
<td>0.112</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>62.69 ± 10.86</td>
<td>0.443</td>
<td>64.38 ± 14.99</td>
<td>0.535</td>
<td>0.273</td>
</tr>
<tr>
<td>Body Weight (kg)</td>
<td>24.90 ± 3.56</td>
<td>0.194</td>
<td>24.25 ± 3.88</td>
<td>0.107</td>
<td>0.544</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>3.56 ± 0.96</td>
<td>0.061</td>
<td>3.5 ± 1.03</td>
<td>0.060</td>
<td>0.719</td>
</tr>
<tr>
<td>NPRS pre</td>
<td>17.69 ± 2.97</td>
<td>0.309</td>
<td>16.96 ± 2.66</td>
<td>0.445</td>
<td>0.483</td>
</tr>
<tr>
<td>VO(_{2}) Max pre (ml.kg(^{-1}).min(^{-1}))</td>
<td>14.66 ± 4.45</td>
<td>0.149</td>
<td>14.18 ± 4.21</td>
<td>0.094</td>
<td>0.801</td>
</tr>
</tbody>
</table>

DISCUSSION

The homogeneity of age, gender and body mass index that affects the value of VO\textsubscript{2} max and 25(OH)D levels. Based on research from Kim, Wheatley, Behnia and Johnson in 2016, VO\textsubscript{2} max is influenced by age, gender and body mass index.\textsuperscript{10} In this study, the mean VO\textsubscript{2} max in the treatment group and control group were 17.69 ± 2.97 and 16.96 ± 2.66, respectively. This mean VO\textsubscript{2} max value is classified as very low according to age and gender. The max VO\textsubscript{2}95 value decreases gradually with age with a decrease rate of about 10% per decade after the age of 25 years, and 15% between the ages of 50 and 75 years. Previous metaanalysis studies mentioned an age-related decline in max VO\textsubscript{2} of 0.40; 0.39 and 0.46 ml/kg/min per year for trained, active and sedentary men and 0.35; 0.44 and 0.62 ml/kg/min per year for women with trained, active and sedentary behaviors, respectively. The age-related decline in max VO\textsubscript{2} is influenced by several factors such as a decrease in maximal heart rate and stroke volume, a decrease in blood volume due to blood stagnation due to inefficient pumping of muscle valves in the extremities, thickening of the heart muscle and blood vessels and reduced oxygen extraction in the periphery. Sarcopenia in old age can cause a reduction in VO\textsubscript{2} max of about 15% per year due to reduced muscle mass and strength. Men have higher VO\textsubscript{2} max values than women. This is related to the muscle mass of men is higher than women and the hemoglobin levels of men are higher than women of the same age.\textsuperscript{11}

Research from Mondal and Mishra in 2017 regarding the effect of body mass index on VO\textsubscript{2} max states that there is a relationship with a negative correlation of BMI and VO\textsubscript{2} max of -0.3232 with significant results which means that there is a decrease in VO\textsubscript{2} max value along with an increase in BMI.\textsuperscript{12}

In general, the degree of low back pain is associated with a decrease in max VO\textsubscript{2} as an estimate for functional capacity. The few studies that have been conducted mention varied results. Some studies found an increase in VO\textsubscript{2} max with a decrease in pain, but other studies stated that there was no relationship between pain and VO\textsubscript{2} max. However, most stated that the higher the VO\textsubscript{2} max value, the more active a person’s functional status is so that the intensity of pain decreases.\textsuperscript{13}

Based on recommendations from the American Institute of Medicine and the American Health Society, optimal 25(OH) D levels are above 20 ng/ml. Subjects in this study obtained a mean 25 (OH) D of 14.66 ± 4.45 in the treatment group and 14.18 ± 4.21 in the control group. This value is included in the deficiency category. Based on research conducted by Jukic et al., 2019 states that the value of 25 (OH)D in women is lower than that of men as well as in subjects with older age groups.\textsuperscript{14} Based on research from Divakar et al., 2020, the prevalence of 25(OH)D deficiency in office workers was 32.9%.\textsuperscript{15} 25(OH)D deficiency in subjects can be influenced by several factors such as low vitamin supplementation, inadequate intake of nutrients containing vitamin D, sun exposure, the habit of using sunscreen or clothes that cover the whole body, and skin color. The study suggested that workplace policies and health programs are needed to encourage workers to take regular breaks to go outside the building to get sun exposure and consume sufficient amounts of vitamin D-rich foods to maintain optimal vitamin D levels. The effect of BMI on 25(OH)D values can be explained that a person who has a higher BMI shows higher levels of body fat and thus has a lower 25(OH)D value because fat is a reservoir of 25(OH)D thus reducing its circulation in the blood. Animal experiments have shown that body adipose tissue can store 10-12% of additional vitamin D levels in the body.\textsuperscript{16} Based on research from Gokcek and Kaydu (2018) with low back pain subjects aged 18-70 years stated that there was a relationship between the degree of pain and 25 (OH)D levels. Pain intensity is higher in the group of subjects with lower 25(OH)D values, although in general 25(OH)D deficiency is asymptomatic.\textsuperscript{17}

Physical exercise is an important strategy to reduce the risk of musculoskeletal diseases, especially those associated with inflammatory profiles. Regular physical exercise can lead to loss of fat mass and adipose tissue, which are known to contribute to systemic inflammation.\textsuperscript{18} Aerobic exercise is an exercise that uses large muscle groups that can increase maximal oxygen consumption (max VO\textsubscript{2}). Research conducted by Butar et al., 2019 states that walking aerobic exercise causes stimulation of increased heart rate and respiratory rate so that it can increase the value of VO\textsubscript{2} max.\textsuperscript{19}
The results of this study are in line with research conducted by Shnayderman and Katz-Leurer, (2013) which provides additional walking exercises using a treadmill on low back pain subjects for 6 weeks. The increase in max VO$_2$ occurred due to an increase in walking speed measured in the 6-minute walk test. The study explained that walking speed in subjects with chronic low back pain was significantly lower at 0.92 m/s when compared to healthy subjects in the same age group. Walking speed in subjects given aerobic exercise walking from 0.8 m/s to 1.4 m/s compared to the control group.

Research conducted by Gopika and Dinakaran, 2017 on the subject of chronic low back pain in nursing staff by providing low back pain exercises consisting of core muscle strengthening exercises, spinal flexibility exercises and stretching exercises performed 3 times per week for 8 weeks resulted in improvements in max VO$_2$ values. This is because after 6-8 weeks of regular exercise can increase 50% the number of mitochondria in the muscle and this number will decrease drastically in 2 weeks after the exercise is stopped. Regularly trained individuals have 3-4 times the number of mitochondria compared to untrained individuals. Another mechanism that causes an increase in max VO$_2$ besides local muscle toning exercises is diaphragmatic breathing exercises which can increase oxygen utilization during exercise.

In this study, it also occurred because the treatment group and control group received conventional exercises, one of which was diaphragmatic breathing exercises.

The results of the increase in 25(OH)D values in this study are in line with research conducted by Aly et al., 2016 who conducted aerobic exercise for 4 weeks in a group of sedentary subjects for 60 minutes twice a week conducted indoors which caused a significant increase in 25(OH)D values. Another study that is in line with this research is the research of Farag et al., 2019 which provides aerobic exercise for 12 weeks with a frequency of 30 minutes per day three times a week. The increase in 25(OH)D value is mediated by an increase in vitamin D receptor activity found in skeletal muscle that occurs during exercise. Increased 25(OH)D associated with exercise provides better neuromuscular performance characterized by an increase in type II muscle fiber groups. The increase in 25(OH)D value is influenced by the type of exercise, exercise intensity, exercise duration and sun exposure during exercise.

In this study, the value of the effect size after the addition of aerobic walking training for 8 weeks was calculated by Cohen's d. The results of the effect size for max VO$_2$ value in the treatment group amounted to 3.13, and the control group amounted to 1.99 which indicates that the addition of walking aerobic exercise in the treatment group and conventional exercise alone in the control group provides a strong effect on improving VO2 max value while the effect size of serum 25(OH)D levels in the treatment group was 0.41 and in the control group was 0.38 which indicates that the addition of walking aerobic exercise in the treatment group and conventional exercise in the control group provides a low effect in increasing 25(OH)D levels.

VO$_2$ Improvement max is important in determining a person's peak performance which provides an advantage to the endurance component which plays a role in determining the ability to do work over a period of time. Walking as aerobic exercise can improve vascular endothelial function. Aerobic exercise can induce the release of Nitric Oxide (NO) in the vascular endothelium. The availability of NO improves the Flow Mediated Dilation (FMD) of blood vessels. This will lead to a vasodilatory effect to protect cardiovascular function. This is in line with the increased oxidative metabolic capacity of active skeletal muscle resulting in increased mitochondrial protein and increased capillarization. This increase in capillarization and mitochondria in the muscle will cause the efficiency of muscle performance to be better so that it can improve the ability of muscles to contract.

The increase in max VO$_2$ was in line with the increase in 25(OH)D values in each group, but the increase in 25(OH)D was not significantly different in the two groups. An increase in 25(OH)D value is associated with an increase in exercise capacity and exercise can increase the systemic concentration of 25(OH)D.

Regular exercise may increase 25(OH)D concentrations because it is done outdoors and thus has the potential to be exposed to sunlight. However, other studies have shown that vitamin D supplementation done indoors can increase 25(OH)D levels without UV exposure, thus eliminating the potential opportunity of sun exposure in the formation of vitamin D in the skin. Therefore, based on this explanation, exercise performed indoors can also increase 25(OH)D levels. Acute sun exposure during outdoor exercise cannot directly increase 25(OH)D levels quickly but requires time gradually. This event will affect the addition of the maximum serum 25(OH)D concentration which is influenced by the time of blood collection. Therefore, it is recommended that a study be conducted that examines the effects of exercise either indoors with no exposure to the effects of UV light or outdoors.

The increase in 25(OH)D value is influenced by the type of exercise, exercise intensity, exercise duration and sun exposure during exercise. In this study, exercise was carried out flexibly, walking aerobic exercise can be done indoors and outdoors and when the subject has time to do the exercise (there is no specific time limit for exercise) so that it can affect the value of 25(OH)D in the subject's body.

Improvements in VO$_2$ max values occurred in both the treatment and control groups, but improvements in the treatment group were better than the control group. The improvement in the difference in VO$_2$ max values between groups was not comparable to the improvement in the difference in 25(OH)D values between groups. This study is not in line with the research of Mowry et al. Examining the relationship of cardiorespiratory fitness (VO$_2$ max) with 25(OH)D in 59 healthy young women, aged 16-24 years. There was a positive relationship between VO$_2$ max and serum 25(OH)D (r =0.36 p<0.05). This study confirmed a direct relationship between vitamin D levels and VO$_2$ max (r=0.29, p<0.0001), in both men and women across a wide age range (20 -73 years) and serum 25(OH)D levels (10 to 82 ng/ml.). The positive association between vitamin D levels and VO$_2$ max...
vitamin D metabolites are also released when stored triacylglycerol is hydrolyzed, is estimated to increase adipose tissue sensitive lipase (HSL). Fasting exercise adipocyte lipids by the action of adipose to hydrolysis of triacylglycerols from adipose tissue. During exercise, ANP are stimulatory lipolytic hormones, blood flow. Glucagon, adrenaline, and atrial natriuretic peptide (ANP) and a decrease in plasma insulin levels in summer did not affect VO₂ max values. Research from Książek et al., 2016 states that individuals with low activity levels show a strong relationship between 25(OH)D₃ and VO₂ max. A 1 SD increase in 25(OH)D can increase VO₂ max level by 8% in subjects with low activity levels. In moderate light-intensity exercise, an increase in 25(OH)D can also lead to a 5% increase in VO₂ max in the group of subjects with moderate activity, and only a 0.2% increase in the group of subjects with high activity.

According to research by Irawati et al, 2021 which provides aerobic exercise with a treadmill with moderate intensity, 30 minutes, for 4 weeks in subjects with diabetes mellitus, it has the effect of increasing 25(OH)D levels and a significant difference in 25(OH)D in the treatment group. Vitamin D is lipophilic and accumulates substantially in adipocyte tissue. Treadmill exercise is a strong stimulus for lipid mobilization from adipose tissue. During exercise, there is an increase in plasma glucagon, adrenaline, and atrial natriuretic peptide (ANP) and a decrease in plasma insulin along with an increase in adipose tissue blood flow. Glucagon, adrenaline, and ANP are stimulatory lipolytic hormones, and insulin suppression causes a strong increase in lipolysis. This leads to hydrolysis of triacylglycerols from adipocyte lipids by the action of adipose triglyceride lipase (ATGL) and hormone-sensitive lipase (HSL). Fasting exercise is estimated to increase adipose tissue lipolysis twofold to threefold so that when stored triacylglycerol is hydrolyzed, vitamin D metabolites are also released from the lipid droplets.

The mechanism of interaction between the effects of vitamin D on VO₂ max remains unclear. Increased VO₂ max occurs due to increased cardiac output, arterial oxygen composition, shunting of blood to active muscle areas and oxygen extraction from the muscle. Low serum 25(OH)D causes myocardial hypertrophy, increased blood pressure and endothelial dysfunction through vitamin D receptors, which can reduce cardiac output. There is scientific evidence showing that vitamin D deficiency and physical inactivity can cause muscle atrophy and changes in muscle fiber composition from IIA to IIB fibers. Thus explaining that subjects with sedentary behavior have the advantage of aerobic exercise on muscle mass and muscle fibers.

In this study, the comparison of the difference in VO₂ max is not only influenced by 25(OH) levels in serum. VO₂ max measurement results are influenced by age, body weight and gender. Although age, body weight and gender in both research groups were normally distributed and homogeneous, in the treatment group there was a significant difference indicating a significant increase in physical activity obtained from the addition of walking aerobic exercise. However, the difference in 25(OH)D values in the two groups was not found to be significant in the two groups due to the concentration of 25(OH)D in serum being influenced by supplementation, nutrition and sun exposure. During training and pauses in training, nutrition and sun exposure in both groups were difficult to control. Skin color and the habit of using sunscreen or clothes that cover the whole body during exercise in the treatment and control groups also affect the 25(OH)D value.

This study has several limitations, among others: 1) The level of physical activity during breaks and during exercise cannot be precisely controlled; 2) The time and place of exercise are flexible, causing sun exposure to the subject cannot be controlled; 3) Nutritional factors that affect 25(OH)D levels cannot be taken into account precisely; 4) This study was conducted at one research locus so that the subjects could not be disguised between the treatment group and the control groups.

**CONCLUSIONS**

From the study result, we concluded that (1) The increase in VO₂ max and 25 (OH) D values was found in the group that received the addition of walking aerobic exercise and conventional exercise and the group that only received conventional exercise for chronic low back pain. (2) The increase in VO₂ max value is better in the group that gets the addition of walking aerobic exercise compared to the group that only gets conventional exercise. (3) The increase in 25(OH)D value was similar in the group that received the addition of walking aerobic exercise compared to the group that only received conventional exercise.

**ACKNOWLEDGMENTS**

Office Workers at Dr. Soetomo General Hospital Surabaya

**ETHICAL APPROVAL**

This study was approved by the Health Research Ethics Commission at Dr. Soetomo General Hospital Surabaya with ethical feasibility number: 0993/LOE/301.4.2/VIII/2022.

**CONFLICT OF INTEREST**

No potential conflict of interest was reported by the authors.

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**AUTHORS’ CONTRIBUTIONS**

INBS, DT, A, MA, SWM contributed to concepts, design, definition of intellectual content, literature search, experimental studies, data acquisition, data analysis, statistical analysis, manuscript preparation, manuscript editing, manuscript review and guarantor of the paper and agreed to be responsible for all the aspects of this work; S,M contribution about data analysis and statistical analysis.
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