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Effect of the Indonesian scientific exercise guidelines for adults with spinal cord injury on quality of life in patients with chronic spinal cord injury

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ABSTRACT

Background: Spinal cord injury (SCI) impairs motor and autonomic function and is often associated with reduced quality of life (QOL). Although the Scientific Exercise Guidelines for Adults with Spinal Cord Injury (SEG-SCI) have been shown to improve fitness and QOL, their effectiveness has not been evaluated in Indonesia. This study examined the effect of implementing the Indonesian adaptation of SEG-SCI on QOL in individuals with chronic SCI.

Methods: A randomized controlled trial with a pre–post design was conducted in seventeen individuals with chronic SCI. Participants were randomly allocated to the control group (n= 9) and intervention group (n= 8). The intervention group completed a 12-week exercise program based on the Indonesian version of SEG-SCI in addition to usual care, and control group underwent observation at the start and at the end of the study. QOL was assessed using the SF-36 before and after the intervention.

Results: Five people (45%) in the control group and six people (55%) in the intervention group said they did moderate amounts of physical activity every day, according to activity diary records. Participants in the intervention group showed a significant improvement in QOL, with a mean increase of 13.12 ± 6.7 points on the SF-36 ($p = 0.001$, $d = 1.19$), whereas the control group showed negative change of -7.5 ± 4.71 after a 12-week intervention period ($p = 0.001$, $d = 0.44$).

Conclusion: A 12-week exercise program based on the Indonesian adaptation of SEG-SCI safely improves quality of life in individuals with chronic SCI. Participants who followed the guideline-based program showed clinically relevant improvements, whereas those in the control group, who did not receive structured exercise, experienced a decline in quality of life over the same period.

Keywords: Aerobic exercise, quality of life, resistance exercise, scientific exercise guidelines for adults with spinal cord injury, spinal cord injury.

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INTRODUCTION

Spinal Cord Injury (SCI) is a very serious condition that can change a person's life in a big way. SCI can't be completely cured, and people who have it have to go through long-term medical care and rehabilitation, which puts a lot of stress on their bodies, finances, and emotions.[1] Globally, the annual incidence of SCI is estimated to range from 40 to 80 new cases per one million population, corresponding to approximately 250,000 to 500,000 new cases each year.[2] In contrast to neighboring Southeast Asian countries with emerging SCI registries and reports, epidemiological data on SCI in Indonesia remain limited. In 2014, a total of 104 SCI cases were reported at Fatmawati General Hospital, consisting of 37 traumatic and 67 non-traumatic cases.[3] Furthermore, between January and August 2023, 41 patient visits related to SCI were recorded at the Medical Rehabilitation Department of Dr. Soetomo General Hospital. Dr. Soetomo General Academic Hospital serves as a referral hospital for East Java, receiving patients referred from both primary and secondary healthcare facilities. Consequently, although the number of visits in this study is lower than that reported by some previous institutions, the patients represent more complex cases that are commonly managed at the tertiary-care level.

SCI makes it hard to control voluntary skeletal muscles and the autonomic nervous system. It has both acute and chronic phases, and it goes through a series of harmful processes that include ischemia, oxidative stress, inflammatory responses, activation of apoptotic pathways, and problems with movement, all of which lead to physical deconditioning.[4,5] Ischemia and oxidative stress have important effects on the body that go beyond their effects on cells. Long-term activation of these pathways can cause muscle problems, early fatigue, and less physical ability, which can make it hard to move around and do everyday tasks. Over time, these functional limitations not only make life less enjoyable, but they also encourage people to be less active, which can lead to cellular damage that raises the risk of heart disease, type II diabetes, and osteoporosis.[6,7] People with SCI often have more than just physical problems. They also get tired, anxious, depressed, and less confident in their ability to do physical activity than people who don't have disabilities.[8] Limited functional capacity further restricts their ability to participate in physical activity.[8,9] Previous research demonstrated a substantial difference in mean quality of life between individuals with and without SCI, with a large effect size (−0.77).[10] Similarly, another meta-analysis confirmed a global reduction in quality of life among individuals with SCI, predominantly affecting the physical functioning domain.[11] To date, no studies in Indonesia have specifically investigated quality of life among patients with SCI.

Specific exercise guidelines for individuals with SCI were first established in 2011, known as the SEG-SCI. These guidelines define the minimum duration and intensity of exercise required to achieve improvements in cardiorespiratory fitness and muscle strength among individuals with SCI. The recommended exercise components include 20 minutes of aerobic training performed at moderate to vigorous intensity twice per week, as well as three sets of resistance training targeting major shoulder and hip muscle groups, also conducted at moderate to vigorous intensity twice per week. Increasing aerobic exercise to 30 minutes at moderate to vigorous intensity three times a week may provide additional benefits, especially for cardiometabolic health.[6,12] Exercise programs based on the SEG-SCI were successful in enhancing cardiometabolic health, muscular strength, and muscle function in patients with acute spinal cord injury in Australia, India, and Norway.[13] However, it may not be right to directly apply these results to Indonesia. The Indonesian healthcare system exhibits variability in access to specialized rehabilitation services, constrained availability of advanced assistive technologies, and disparities in post-discharge follow-up. Cultural factors, such as significant family involvement in daily care and unique domestic activity patterns, may also impact functional priorities and perceived quality of life in individuals with SCI. Environmental limitations and contexts with restricted rehabilitation resources highlight the necessity for local validation of SEG-SCI to ascertain its clinical significance and practicality within the Indonesian framework.

A 2018 study showed that people with chronic SCI who did moderate-intensity upper-limb aerobic exercise four times a week for six weeks had big improvements in their quality of life, both physically and mentally, as shown by the physical and mental component summaries of the Short Form-36 (SF-36).[8] The SF-36 is a well-known tool for measuring quality of life that has been tested in many countries and populations around the world.[14] In Indonesia, there is a lot of proof that the SF-36 is valid and reliable. This includes its use in people aged 46 to 81 years15, people with rheumatoid arthritis16, and people with permanent cardiac pacemakers.17 The SF-36 is a general test that has been shown to measure changes in both physical and mental health. These are important outcomes that exercise programs for people with spinal cord injury are supposed to improve.[8] The SF-36 was prioritized over SCI-specific instruments to allow assessment of broader health-related physical and mental dimensions that are expected to change with exercise-based interventions.

The SEG-SCI say that aerobic exercise for the upper body is one of the most important types of exercise. Many people around the world, including Indonesia, have translated these guidelines into many languages and used them.[12] But so far, there have been no published studies that look at whether or not exercise programs based on these guidelines work in Indonesia. The Indonesian version of the SEG-SCI included not just translating the language but also changing the exercises to fit local rehabilitation practices, available resources, and common ways of being active. This study is an early look at how the Indonesian version of the SEG-SCI translation might affect the quality of life of people with chronic SCI.

METHODS

The study employed an experimental design with both intervention and control groups (controlled trial). Data were collected before and after the intervention using a pre–post test approach, with participants allocated through randomization. This study was conducted as a single-blind, open-label randomized controlled trial (pre-test and post-test single-blind RCT). Simple randomization was performed using a sealed-envelope draw, in which participants selected an envelope containing a paper indicating allocation to either the intervention or control group, ensuring allocation concealment until assignment. This study was conducted at the outpatient clinic of the Medical Rehabilitation Department, Dr. Soetomo General Hospital, Surabaya, as well as at the participants' respective homes from September 2023 to June 2024. This study includes individuals with chronic SCI (onset >1 year, of either traumatic or non-traumatic etiology), aged 18–59 years, with a neurological level of injury at T1 or below. Participants were required to have a body mass index (BMI) between 18.5 and 29.9 kg/m², systolic blood pressure of 110–130 mmHg and diastolic blood pressure of 70–90 mmHg. This blood pressure range was applied to ensure baseline cardiovascular stability and participant safety, given the altered autonomic regulation commonly observed in chronic spinal cord injury. Additional inclusion criteria included no participation in regular exercise within the preceding six months and willingness to voluntarily participate in the study by providing written informed consent.

The exclusion criteria included a history of cardiovascular disease (including cardiac arrhythmias and coronary artery disease), acute exacerbation of restrictive or obstructive pulmonary disease, hearing impairment, pregnancy, moderate to severe depressive disorder (Hamilton Depression Rating Scale score ≥ 17), cognitive impairment, alcohol or illicit substance dependence, communication disorders, class II obesity (body mass index ≥ 30 kg/m²), American Spinal Injury Association Impairment Scale (AIS) grade E, and unwillingness to participate in the study.

The control group underwent observation at the start and at the end of the study period (12 weeks) without receiving any additional treatment to the basic program. The intervention group was assessed before and after participation in a 12-week exercises program based on the Indonesian version of the SEG-SCI translation in addition to the basic program. The program consisted of 20 minutes of aerobic exercise performed at moderate to vigorous intensity twice per week, followed by three sets of resistance training targeting the shoulder and hip muscle groups at moderate to vigorous intensity, also conducted twice per week. The total intervention duration was 12 weeks. They received detailed explanations regarding potential exercise-related discomfort, criteria for temporary exercise cessation, and procedures for reporting any symptoms experienced during training. Participants were also provided with instructional exercise videos to support proper exercise execution. Throughout the intervention period, participants in the intervention group were required to complete an exercise diary after each session as well as a daily activity diary to facilitate monitoring and adherence assessment. During the home-based exercise program, participants were monitored by the research team once every two weeks.

Before starting the exercise program, some rules were put in place. The target heart rate (THR) was determined from the results of an arm ergometer workout test. For moderate-intensity exercise, the THR was set at 60% of peak oxygen consumption (VO_2peak) or calculated using the heart rate reserve (HRR) method. The formula THR = resting heart rate + 60% HRR was used, where HRR is found by taking 220 minus age minus resting heart rate. The Borg Rating of Perceived Exertion scale was used to measure how hard the exercise was. The goal was to get a score between 13 and 14, which means the activity was moderate-intensity, with a higher heart rate and breathing, but not so much that it caused shortness of breath. We found the right resistance band level for each person by looking at their 10-repetition maximum (10-RM). The resistance levels ranged from yellow (4.4 kg) to blue (6.7 kg), red (9.0 kg), green (11.3 kg), and black (13.6 kg).

Resistance training was implemented in the form of isometric exercises with a minimum frequency of two sessions per week. The intervention protocol comprised five upper-limb movements, including shoulder flexion, shoulder abduction, shoulder extension, elbow flexion, and elbow extension. Each movement was completed in three sets, with every isometric contraction maintained for five seconds. A rest interval ranging from 30 to 60 seconds was provided between sets. To enhance participant adherence and minimize fatigue, the exercise components could be distributed into two separate sessions within the same day, for instance, three movements conducted in the morning followed by the remaining two movements in the afternoon.

Aerobic training was also prescribed at a minimum frequency of twice weekly and consisted of multidirectional boxing-based movements involving the upper extremities. Each session lasted at least 20 minutes and could be performed either as a continuous session or divided into two 10-minute segments. Individual movements were executed for one minute and repeated sequentially throughout the session. A target cadence of 100 repetitions per minute was maintained with the assistance of a metronome. All sessions were supervised by a therapist, and task adjustments were implemented as required to ensure that participants with varying levels of neurological impairment were able to perform the exercises safely and in accordance with the prescribed tempo.

Participants got a pulse oximeter to use while they worked out at home and resistance bands to use for strength training. The research team checked on safety and adherence by making phone or video calls every other week. If participants showed signs of extreme fatigue, the exercise session was quickly stopped and they were told to rest. They could start exercising again after they had fully recovered. Exercise was stopped for a short time if the person had chest pain, shortness of breath, dizziness, a headache, nausea, pale skin, or flushing; shoulder pain with a visual analog scale (VAS) score above 4; a resting heart rate above 100 beats per minute; signs of poor perfusion shown by oxygen saturation (SpO_2) below 90%; a body temperature above 37.5°C; or syncope.

Before and after the intervention, we used the SF-36 questionnaire to find out how good life was. The SF-36 is a general tool with 36 questions that is used to measure health-related quality of life (HRQoL). It has been proven to be accurate and useful for people with SCI. The SF-36 looks at quality of life in two main ways: the Physical Component Summary (PCS) and the Mental Component Summary (MCS). The MCS looks at mental health and the PCS looks at physical health.

The PCS has four parts: physical functioning (PF), which looks at how well a person can do everyday physical tasks; role physical (RP), which looks at how physical health problems affect a person's ability to do their job; bodily pain (BP), which looks at how much pain a person has and how it affects their daily life; and general health (GH), which looks at how a person feels about their overall health. The MCS has four parts: vitality (VT), which looks at how tired or energetic you are; social functioning (SF), which looks at how well you participate in social activities; role emotional (RE), which looks at how emotional problems affect your role; and mental health (MH), which looks at your mental health, including symptoms of anxiety and depression.

The SF-36 was administered and the statistical analyses were conducted by individuals who were not involved in the intervention procedures and were unaware of group allocation. Each SF-36 domain is scored on a scale ranging from 0 to 100, with higher scores indicating better quality of life. Scores are calculated according to standardized SF-36 scoring guidelines, and analyses are conducted separately for each domain as well as generating a single overall total score.

Data analysis was done using SPSS version 26.0. Data normality was assessed using the Shapiro–Wilk test. Parametric statistical tests were applied to normally distributed data, while non-parametric tests were used for data that were not normally distributed. Within-group comparisons of quality-of-life outcomes before and after the intervention in both the control and intervention groups were conducted using a paired t-test for normally distributed data or the Wilcoxon signed-rank test for non-normally distributed data. Between-group comparisons of post-intervention values and change scores were analyzed using an independent samples t-test for normally distributed data or the Mann–Whitney U test for non-normally distributed data. Effect sizes were calculated to quantify the magnitude of differences. Cohen's *d* was used for parametric comparisons. Results are presented with corresponding 95% confidence intervals (95% CI) where applicable. A p-value of < 0.05 was considered statistically significant.

RESULTS

There were 17 people in this study. They were split into two groups: an intervention group (n = 8) and a control group (n = 9). The people in the intervention group did an exercise program based on the International Scientific Spinal Cord Injury Exercise Guidelines for 12 weeks (3 months). The program included 20 minutes of moderate-intensity aerobic exercise twice a week, followed by three sets of shoulder muscle strengthening exercises done at home twice a week. During the study, all participants were free to go about their normal daily lives, and they had to write down what they did in a daily activity diary. Five people (45%) in the control group and six people (55%) in the intervention group said they did moderate amounts of physical activity every day, according to activity diary records. Three participants (60%) in the control group and two participants (40%) in the intervention group said they were doing light activities. The intervention group followed the exercise program 86.63% of the time.

Demographic and clinical characteristics of participants in both groups are presented in Table 1. No significant differences were observed between the intervention and control groups with respect to age, sex, Montreal Cognitive Assessment–Indonesian version (MoCA-INA) scores, Hamilton Depression Rating Scale (HDRS) scores, injury etiology, educational level, comorbidities, injury severity, income level, and baseline SF-36 Scores. Baseline domain-level SF-36 scores are not shown because of space limitations, PCS and MCS are therefore presented as composite outcomes.

Table 1. Characteristics of participants in the intervention and control groups

Characteristics	Intervention (n = 8)	Control (n = 9)	P-value
	Mean±SD or n(%)	Mean±SD or n(%)	
Age	30.5 ± 13.44	37 ± 12.2	0.484[a]
Sex			
Male	3 (37.5)	4 (44.4)	0.702[b]
Female	5 (62.5)	5 (55.6)	
Barthel Index	88.13 ± 11.9	73.8 ± 16.1	0.277[a]
MoCA-INA score	29.38 ± 0.74	29 ± 1.2	0.912[a]
HDRS score	4.63 ± 2.26	3.78 ± 1.2	0.211[a]
Etiology			
Traumatic	5 (62.5)	7 (77.8)	0.541[b]
Non-Traumatic	3 (37.5)	2 (22.2)	
Education level			
Primary school	-	3 (33.3)	0.092[b]
Junior high school	-	2 (22.2)	
Senior high school	4 (50)	1 (11.1)	
Diploma–Bachelor degree	4 (50)	3 (33.3)	
Monthly income			
< 1 million IDR	6 (75)	5 (55.6)	0.769[c]
1–3 million IDR	1 (12.5)	3 (33.3)	
> 3 million IDR	1 (12.5)	1 (11.1)	
Medical history			
(hypertension/diabetes/ dyslipidemia/heart disease/ smoking)			
Present	1 (12.5)	1 (11.1)	0.706[b]
Absent	7 (87.5)	8 (88.9)	
AIS Classification			
AIS A	-	2 (22.2)	0.274[b]
AIS B	-	2 (22.2)	
AIS C	1 (12.5)	-	
AIS D	7 (87.5)	5 (55.6)	
Marital status			
Unmarried	4 (50)	1 (11.1)	0.110[b]
Married	4 (50)	8 (88.9)	
Baseline quality of life (SF-36)			
Total SF-36 score	55.25 ± 11.25	51.88 ± 18.06	0.492[a]
Physical component summary	51.12 ± 13.73	39.33 ± 17.79	0.645[a]
Mental component summary	59.75 ± 12.87	64.33 ± 20.18	0.329[a]

[a], Levene's test; [b], Chi-square test; [c], Spearman's correlation test; n, frequency of participants; %, percentage of participants; SD, standard deviation.

Changes in SF-36 scores were evaluated using the mean change in scores after 12 weeks of intervention compared with baseline values. The Shapiro–Wilk test confirmed that all data were normally distributed; therefore, paired-samples t-tests were performed. In the intervention group, a statistically significant improvement in overall quality of life was observed, with a mean SF-36 score increase of 13.12 ± 6.70 (p = 0.001), representing a large effect size (Cohen's d = 1.19), Notably, the observed mean increase in SF-36 score (13.12 ± 6.7) exceeds the reported minimal clinically important difference for individuals with spinal cord problem, indicating that the improvement was not only statistically significant but also clinically meaningful.18 Significant improvements were also noted in both SF-36 subcomponents. The PCS score increased by 13.50 ± 9.24 (p = 0.004; d = 1.04), reflecting a large effect on physical functioning, while the MCS score increased by 12.00 ± 8.08 (p = 0.004; d = 0.87), corresponding to a moderate-to-large effect on psychosocial well-being (**Table 2**).

Table 2. **Changes in quality of life in the intervention group (n = 8)**

Parameter	Week 0 Mean±SD	Week 12 Mean±SD	Delta Mean±SD	P-*value*	Effect size
SF-36 Total Score	55.25 ± 11.25	68.37 ± 10.63	13.12 ± 6.7	0.001[a,*]	1.19
SF-36 Physical Component	51.12 ± 13.73	64.62 ± 12.11	13.5 ± 9.24	0.004[a,*]	1.04
SF-36 Mental Component	59.75 ± 12.87	71.75 ± 14.52	12 ± 8.08	0.004[a,*]	0.87

*, *P*-value is considered statistically significant if p < 0.05; [a], Paired t-test; n, frequency of participants; SD, standard deviation.

Table 3. **Changes in quality of life in the control group (n = 9)**

Parameter	Week 0 Mean±SD	Week 12 Mean±SD	Delta Mean±SD	P-*value*	Effect size
SF-36 Total Score	51.88 ± 18.06	44.33 ± 15.89	-7.5 ± 4.71	0.001[a,*]	0.44
SF-36 Physical Component	39.33 ± 17.79	31.77 ± 16,65	-7.5 ± 4.77	0.001[a,*]	0.43
SF-36 Mental Component	64.33 ± 20.18	56.77 ± 17,19	-7.5 ± 6.61	0.009[a,*]	0.40

*, *P*-value is considered statistically significant if p < 0.05; [a], Paired t-test; n, frequency of participants; SD, standard deviation.

In the control group, alterations in SF-36 scores were assessed by comparing the mean change in scores after 12 weeks to baseline values. The Shapiro–Wilk test verified that all data had a normal distribution; hence, paired-samples t-tests were conducted. The control group exhibited a statistically significant reduction in overall quality of life, as assessed by the SF-36, with a mean change of −7.50 ± 4.71 (p = 0.001), indicating a small-to-moderate effect size (Cohen's d = 0.44). Deterioration was also apparent in both subcomponents of the SF-36. The PCS score diminished by −7.50 ± 4.77 (p = 0.001; d = 0.43), but the MCS score fell by −7.50 ± 6.61 (p = 0.009; d = 0.40), signifying small-to-moderate adverse effects on the physical and mental health domains, respectively (**Table 3**). The noted small-to-moderate decrease in the control group was seen across several SF-36 categories, with both physical and psychosocial components exhibiting slight reductions, although the extent of change differed among domains.

After 12 weeks, there was a big difference in the quality-of-life changes between the intervention and control groups. The average change in the total SF-36 score was much bigger in the intervention group than in the control group. This shows that the exercise program had a clear positive effect, according to the International Scientific Spinal Cord Injury Exercise Guidelines. Participants in the intervention group had a clinically and statistically significant improvement in their overall quality of life, while participants in the control group saw a significant drop in their quality of life over the same time period.

Also, comparing the SF-36 subcomponents showed that there were big differences between groups in the MCS and PCS scores. The intervention group saw big improvements in both their mental and physical health, while the control group saw a decline in both areas. The results show that the structured exercise intervention, not just natural recovery or everyday activities, was what made the participants' quality of life better.

DISCUSSION

This study investigated the influence of the Indonesian translation of the SEG-SCI on quality-of-life outcomes in individuals with chronic spinal cord injury. The findings support our primary hypothesis, indicating that a structured exercise regimen comprising 20 minutes of aerobic training at moderate-to-vigorous intensity biweekly, alongside three sets of moderate-to-vigorous resistance exercises focusing on the principal shoulder and hip muscle groups performed biweekly, results in substantial enhancements in health-related quality of life in both physical and mental aspects among individuals with spinal cord injury.

Physical exercise has consistently been shown to exert beneficial effects on quality of life in individuals with SCI, encompassing both physical and psychosocial dimensions. Structured exercise interventions have been demonstrated to enhance bodily function and improve key domains assessed by quality-of-life instruments such as the SF-36, including general health, vitality, and social functioning.[8,19] Recent meta-analyses further indicate that physical activity significantly improves both the physical and mental components of health-related quality of life in individuals with SCI, although methodological heterogeneity and variability in exercise protocols remain notable challenges.[20,21] From a physiological perspective, regular exercise contributes to improved cardiovascular efficiency, enhanced glucose metabolism, and a reduced risk of secondary complications such as depression and chronic pain.[22,23]

Individuals with chronic SCI exhibit increased expression of pro-inflammatory cytokines, including interleukin (IL)-1β, IL-6, and tumor necrosis factor-α (TNF-α), which contribute to ongoing tissue damage and impaired neural regeneration.[24,25] In parallel, reduced levels of neurotrophic factors such as brain-derived neurotrophic factor (BDNF), which plays a crucial role in neuronal survival and synaptic plasticity, have been reported in this population.[26,27] Neurotransmitter dysfunction, particularly decreased GABAergic activity, has also been observed and is associated with increased spasticity and neuropathic pain following SCI.28,29 Aerobic exercise has been shown to attenuate the expression of pro-inflammatory cytokines, including IL-1β, IL-6, and TNF-α, while upregulating anti-inflammatory mediators such as IL-10, thereby reducing spinal tissue inflammation.24,25 Exercise training also increases BDNF levels, which supports axonal regeneration and enhances synaptic plasticity.26,27 Furthermore, physical exercise modulates intracellular signaling pathways such as the PKA/CREB pathway, which are involved in neuronal repair and motor function recovery.[28,29]

From a psychological perspective, engagement in physical activity has been shown to enhance self-confidence, reduce anxiety, and improve patients' sense of control over their health condition following SCI.[20,30] Physical activity also serves as an important mediating factor in restoring a sense of purpose and social role, both of which are frequently diminished after spinal cord trauma.[19] Many studies have shown that people who exercise more have a stronger sense of self and feel more connected to others, both of which are important parts of mental health that are measured by the SF-36.[8,20] The psychosocial implications underscore that the benefits of exercise extend beyond physical improvements, encompassing existential and emotional aspects of rehabilitation. The formulation of exercise regimens must incorporate individual psychological requirements as a core component of a holistic rehabilitation approach.

Even though exercise has many well-known benefits, people with SCI often have trouble taking part in structured physical activity programs because of structural and environmental barriers. Limited access to transportation, a lack of facilities that are friendly to people with disabilities, and not enough social support are all major barriers to staying active.[31,32] Evidence from the SCI-HOME-ACTIVE study indicates that supervised home-based exercise programs facilitated through remote or digital platforms may represent a viable alternative to promote sustained participation among individuals with SCI.[20,31] In Our study achieved a high adherence rate (86.63%), primarily facilitated by bi-weekly monitoring, while regular motivational feedback and problem-solving discussions during follow-up contacts were instrumental in maintaining participant engagement. Moreover, personalized exercise interventions customized to individual requirements and functional abilities have demonstrated greater efficacy in enhancing adherence and attaining significant advancements in both physical and psychological aspects.[21,33,34] As a result, the ability of a program to change is a key factor in the success of an intervention.

The conclusion that physical exercise significantly improves quality of life for people with SCI is generally supported by mounting empirical evidence, especially when it comes to general health, physical, emotional, and social domains as measured by SF-36 scores. The length of the program, the type of exercise, the intensity of the training, and the accessibility of social and technological support networks all have a significant impact on how effective exercise interventions are.[20,31] For sustainable exercise to be implemented successfully, individualized and interprofessional collaborative approaches are crucial, given the complex and multifaceted needs of people with SCI.[21,23] Furthermore, to guarantee the sustainability of long-term benefits, multidimensional evaluation and longitudinal monitoring are necessary. As a result, physical activity ought to be a key component of functional rehabilitation plans meant to enhance the quality of life for people with SCI.

The SF-36 questionnaire was used in this study to measure quality of life. This is a common tool for measuring health-related quality of life in people with SCI. The SF-36 includes eight main areas that cover physical, mental, and social aspects of health. These are physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health. This makes it a complete way to measure how patients feel about their health. In the SCI population, the physical functioning and bodily pain domains often produce the lowest scores, underscoring the direct influence of spinal cord injury on mobility and physical well-being.[8] However, deficits in emotional regulation and social functioning are frequently noted, indicating disturbances in social roles and identity subsequent to injury.[19,31] Because of this, domain-specific analysis is very important for creating rehabilitation programs that are targeted and work.

Significant improvements after the intervention are most often seen in physical functioning, bodily pain, and vitality. This shows that exercise has a direct effect on physical performance and physiological capacity.[20,21] Studies that involved upper-limb exercise programs that lasted about 12 weeks showed significant improvements in these areas. This suggests that gains in muscle strength and cardiovascular capacity lead to better perceptions of physical quality of life.[22,23] Improvements in vitality mean more energy and less tiredness, which are indirect signs that physical activity can improve mental health.[19,30] Also, improvements in pain scores in the body suggest that exercise may help with chronic pain by working on the nervous system or improving blood flow in the area.[35,36] These results all point to the importance of exercise in changing important physical aspects of daily life for people with SCI.

Although enhancements in physical domains seem to be relatively stable, variations in mental health, emotional role, and social functioning domains exhibit greater inconsistency across studies. Community-based or group exercise interventions typically produce more significant advantages in social and emotional aspects compared to individually conducted or home-based programs.[31] When people do physical activity together, it helps them connect with each other and get emotional support, both of which are important for getting used to life after a SCI.[20,30] Not all participants exhibit significant improvements in mental health domains; however, evidence suggests that interventions incorporating motivational strategies or counseling components are more effective in enhancing these outcomes.[8,19] If you want to get more than just better physical health from exercise programs, these results show that you need to think about psychosocial factors when you design them.

Some SF-36 domains, such as role physical and role emotional, frequently exhibit delayed or diminished responses to exercise interventions. Other health issues or environmental factors can also have an effect on these areas. For instance, individuals with SCI who experience secondary complications such as infections or autonomic dysreflexia are less likely to exhibit enhancements in their physical role functioning.[21,22] Family and friends' support is also very important for emotional role functioning. Someone may not be able to get better mentally even if their physical health is getting better if they don't get enough support. We can't just blame changes on physical interventions because of this variability. We need to look at domain-specific scores in a bigger picture and environment.[19,31] These things make it even more important to use a multidisciplinary approach to SCI rehabilitation.

Th domain-specific analysis of SF-36 scores offers a more comprehensive and nuanced comprehension of the impact of exercise on the quality of life in individuals with spinal cord injury. While overall SF-36 scores give a general picture, changes in specific areas are often better for judging how well an intervention works.[8,20] This information also helps rehabilitation professionals make interventions more specific. For example, they can add counseling sessions for people with low emotional domain scores or set up progressive exercise programs for people with serious physical limitations.[29] So, the SF-36 is not only a way to measure outcomes, but it is also a way to make informed, personalized clinical decisions. Longitudinal, domain-specific evaluation ought to be regarded as a normative methodology in forthcoming spinal cord injury intervention research.

This study documented the incidence of adverse events in both the intervention and control groups. Monitoring of adverse events indicated that two participants in the intervention group encountered exercise-related side effects, specifically shoulder and back pain during training, with a Wong–Baker Scale (WBS) score of 4. The pain symptoms ameliorated with the implementation of ice therapy for 10 minutes every 6 hours, accompanied by a day of rest. These symptoms manifested in the initial phase of the study (the first and second weeks) and did not reappear in the following weeks until the conclusion of the intervention period. This pattern may indicate a physiological adaptation of the participants to the designated exercise regimen.

One person in the control group fell at home because they tripped. The participant said they had low back pain and a WBS score of 4. The pain went away after 10 minutes of ice therapy every 6 hours and two days of rest. The participant could go back to their normal activities and didn't have any problems with them during the recovery period. Based on these results, the intervention seems safe and possible to use in regular medical practice. These findings endorse the commencement of a pilot SEG-SCI program integrated within the outpatient physiotherapy services at Dr. Soetomo General Hospital as a subsequent measure towards clinical translation.

It is important to recognize the study's limitations. First, this study didn't look at a whole population, so the results can't be applied to other groups. The results are relevant solely to individuals possessing characteristics akin to those of the study participants. Before these results can be used to make more general clinical recommendations or policy suggestions for treating chronic SCI, they need to be confirmed by bigger, more representative studies. Second, the study's statistical power was 80%, but a bigger sample size could have given it more power. The relatively small sample size was mainly due to the fact that there weren't many people who met the inclusion criteria and the fact that transportation issues made it hard to recruit people from outside of East Java. These things might have made the study's results less useful outside of the study. Third, while assessor blinding was employed during the analysis of SF-36 questionnaire data to reduce assessment bias, participant blinding was not achievable. At the beginning of the study, participants were told which group they would be in. This could have led to expectancy bias. People in the intervention group may have thought their condition was getting better because they expected the exercise program to help them. Lastly, this study did not categorize or contrast participants in the intervention and control groups according to sex, American Spinal Injury Association (ASIA) Impairment Scale (AIS) classification, neurological level of injury (NLI), or mechanism of injury. Physiological responses to upper-limb boxing may vary between individuals with high-thoracic and low-thoracic spinal cord injuries, as differences in trunk stability and postural control could affect movement efficiency, fatigue, and exercise intensity. Without subgroup analyses, it's still not clear whether the intervention effects were different for certain patient groups or were stronger for certain clinical profiles.

CONCLUSION

This study demonstrates that a 12-week exercise program based on the Indonesian adaptation of the SEG-SCI guidelines can safely improve quality of life in individuals with chronic spinal cord injury. Participants who followed the guideline-based program showed clinically relevant improvements, whereas those in the control group, who did not receive structured exercise, experienced a decline in quality of life over the same period.

ETHICAL CONSIDERATION

Ethical approval was obtained from the Health Research Ethics Committee of Dr. Soetomo General Academic Hospital, Surabaya, Indonesia (Approval No. 0703/KEPK/VII/2023). All participants have agreed to participated in the study and they provided the written informed consent.

CONFLICT OF INTEREST

None

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AUTHOR CONTRIBUTIONS

ERE, LA, NKW, DP, and IN participated in searching the literature, data collection and statistical analysis, and drafting, reviewing, and editing the manuscript; LA conceived the study design.

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