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Implementing the international exercise guidelines to improve the functional independence among the chronic spinal cord injury patients: A randomized controlled trial

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ABSTRACT

Background: This research investigated the effectiveness of a modified exercise program in accordance with international spinal cord injury (SCI) exercise guidelines for improving functional independence in individuals with chronic SCI.

Methods: A randomized controlled trial with a pre–post assessment design. Chronic SCI patients were allocated to either the intervention or control group. The intervention group participated in a 12-week combined aerobic and resistance training program. Functional independence was measured using the Spinal Cord Independence Measure (SCIM-III) at baseline and post-intervention.

Results: Participants of intervention showed statistically significant improvement in functional independence (SCIM-III scores 79.25 ±19.6 to 86.0±17,8 p=0.018; effect size d = 0,84). The control group showed no meaningful change (56.38 ± 24.48 to 56.88 ± 23.73, p=0.848). Between-group comparison confirmed a significantly greater gain in the intervention group (Δ6.75 ± 6.79 vs. 0.5 ± 7.09, p=0.014; effect size 0.9). No severe adverse events were reported.

Conclusion: A working translation of the International SCI Exercise Guidelines has been tested in Indonesia, showing clear gains in daily living skills. Because these results match global findings, adding planned physical activity to spinal cord injury recovery may work well even where resources are limited.

Keywords: functional recovery, rehabilitation, SCIM III, spinal cord injuries.

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INTRODUCTION

Owing to the loss of motor, sensory, and autonomic control, and the consequent loss of independence and decreased quality of life, spinal cord injury (SCI) is an elaborate and complex neurological condition that leads to permanent disability.[1] Continued SCI brings about an enduring disability that severely limits one's ability to perform activities of daily living (ADLs) and socially participate, while also developing secondary complicating conditions that include the serious and costly healthcare concerns of depression, cardiovascular disease, and musculoskeletal pain.[2] All these factors also greatly depress the quality of life of the injured and their family members.[3]

To mitigate these outcomes, the International Scientific SCI Exercise Guidelines were developed to offer evidence-based recommendations for aerobic and resistance training in persons with SCI.[4-6] These guidelines are beneficial in emphasizing the positive contributions of structured moderate-intensity physical exercise in enhancing cardiovascular fitness, muscle strength, and mental well-being.[6] Although studies on physical exercise in SCI patients are mostly carried out in high-resource countries, its implementation of these exercise guidelines in low- and middle-income resource groups such as Indonesia remains a question mark.[7,8] The lack of existing literature in this area relates to feasibility of implementation of these exercise guidelines in different resource settings, patient compliance with these exercise guidelines, and efficacy of exercise programs on independence in daily living functions in the Indonesian population. In addition, the cultural appropriateness of the interventions is an area of concern which demands local adaptation.[9,10]

The aim of the present study was to explore the impact of exercise interventions among patients with chronic SCI with reference to functional independence, measured by SCI exercise guidelines around the globe. This ensures that functional outcomes are enhanced among patients with chronic SCI. Though the physiological benefits of physical exercise, such as increased muscle strength and improved cardiovascular capacity, have been well described, a clear understanding of how these outcomes contribute to functional capacity as measured by the Spinal Cord Injury Measure (SCIM-III) in the areas of transfers, wheelchair skills, and self-care must be understood in terms of the role of increased muscle strength.[11,12] This is vital in the performance of ADLs.[13]

Built around aerobic movement paired with strength drills, the international SCI exercise guidelines offer clear structure for rehab paths. Muscle power grows mainly through resistance work, while steady activity boosts staying ability - both matter deeply when regaining daily skills. Tasks like moving in a wheelchair or handling personal care rely heavily on force plus lasting energy, making this dual method meaningful. One feeds what the other lacks: together they lift not just physical capacity but heart-lung readiness too. Independence thrives when body systems work in step, not isolation.

METHODS

This study was a randomized controlled trial with a pre–post assessment design to determine the efficacy of a structured exercise program in adults with SCI, as recommended by the International Scientific Exercise Guidelines for Adults with SCI but adapted for Indonesian conditions. The control group continued with regular care. The research was conducted at the Department of Physical Medicine and Rehabilitation, Dr. Soetomo General Hospital, Surabaya, Indonesia. Recruitment and interventions were carried out between August 2023 and July 2024. The total of 16 participants recruited and assigned to intervention and control groups (n = 8 for each group) is limited. Participant flow throughout the trial is presented in the CONSORT 2010 flow diagram (**Figure 1**). The lack of prior sample size or power calculation makes it challenging to assess whether the study is sufficiently powered to detect clinically significant changes in SCIM-III scores. As such, findings should be interpreted with caution, recognizing the limited statistical power due to the small sample size.

Inclusion criteria included adults aged 18-59 years, participants having chronic SCI of more than one year's duration, and neurological levels of T1 or below (traumatic or non-traumatic). Additional criteria included body mass index of 18.5-29.9kg/m^2, systolic blood pressure of 110-130mmHg, and diastolic blood pressure of 70-90mmHg. There was no previous experience of structured training as recommended by international guidelines for SCI. All participants provided written informed consent. Exclusion criteria consisted of having serious cardiovascular disease, respiratory problems, mild or more severe degrees of depression (HDRS ≥17), intellectual impairment, pregnancy, substance dependence, any issues with communication, and AIS E classification. They withdrew participants if they neither consented to participate nor attended more than two consecutive weeks of physical exercise activity.

The intervention was translated from 'Exercise Guidelines for Intensive Scientific Interventions for Adults with SCI into Bahasa Indonesia and made culturally compatible for implementation. The program consisted of aerobic training with a frequency of twice weekly and an intensity ranging from moderate to vigorous. The target heart rate (THR) was determined using the arm ergometer test or calculated with the formula THR = resting HR + 60% HRR, or monitored using the Borg Scale (13–14). The duration was 20 minutes per session or two sets of 10 minutes.

The type of aerobic exercise was boxing. Strength training was performed twice weekly with moderate-to-high intensity based on resistance band levels. Each session comprised three sets, each consisting of a five-second hold period, and focused on exercises for strengthening upper limbs, targeting the shoulder region. The cardiometabolic goal for every participant was to reach at least 30 minutes of moderate-vigorous intensity physical activity per week. For the participants in the intervention group, instructional videos and exercise diaries were provided, and telemonitoring was done using video conferencing or telephone services to ensure that they were strictly adhering to exercises. Contrary, for the control group, they were simply asked to do their routine activities, and diaries were also provided for monitoring, without being instructed or guided on any specific exercise regime. The termination criteria for exercises included experiencing chest pains, breathlessness, dizziness, headache, nausea, paleness, or flushing; experiencing pain in the shoulder region, measured using a visual analogue scale of more than 4; experiencing a heart rate of more than 120 beats per minute; experiencing oxygen saturation of less than 90%; experiencing a temperature of more than 37.5°C; or fainting.

Functionality was generally evaluated

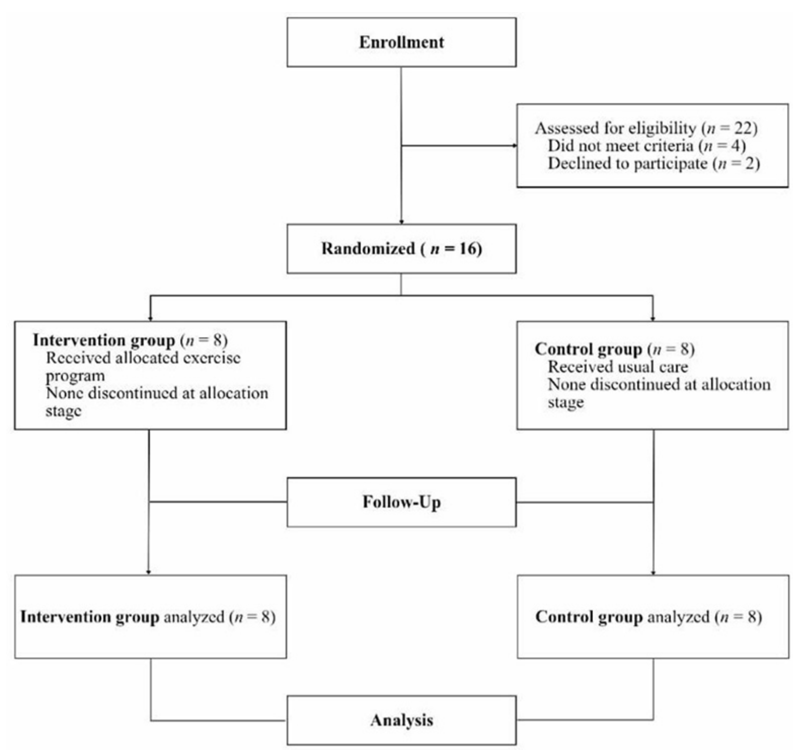

Figure 1. Consolidated standards of reporting trials (CONSORT) flow chart of the study

using the Indonesian version by utilizing the SCIM-III and a standard cross-cultural adaptation process.[14] For this process, the following are done: (1) translation, (2) equivalence, (3) expert, and (4) pilot testing. It includes evaluating the process of validity in terms of self-care, respiration/sphincter control, and mobility by using tests conducted pre- and post-12 weeks, and the researchers are blinded as to who underwent which group interventions.

Participants underwent monitoring for adverse events during each trial. Vital signs, such as blood pressure, heart rate, and oxygen saturation, were measured before and after exercising. Keeping a logbook was used to record attendance and compliance.

Statistical analyses were undertaken through SPSS software. Normality tests used the Shapiro-Wilk test. Paired t-test comparisons (or Wilcoxon signed tests on non-parametric variables) examined pre- and post-test performances within groups. Comparison of inter-group differences was carried out by independent t tests (alternatively, Mann-Whitney U tests). Effect sizes were calculated, and significance was set at $p < 0.05$.

RESULTS

Participant characteristics

Sixteen individuals with chronic spinal cord injury (SCI; duration > 1 year) successfully completed the program. The participants included 37.5% males and 62.5% females, with a mean age of 33 years (SD 12.9, range 19 to 57). Most cases were traumatic (62.5%), while the rest were non-traumatic (37.5%). Baseline comparisons between the groups showed no major differences in demographics, cognitive performance (MoCA-INA), stress levels (HDRS mean 5.06 ± 2.26, indicating mild stress), or SCIM-III scores. Only one subject had hypertension, and no significant comorbidities were found. The statistical comparison of baseline characteristics between the intervention and control groups (**Table 1**) revealed no significant differences in age, educational level, medical history, AIS classification, sex, marital status, etiology, Barthel Index, HDRS, MoCA-Ina, and SCIM III scores. Although no statistically significant baseline differences were detected, numerical differences in SCIM-III scores should be interpreted cautiously, given the small sample size.

Functional outcome changes within groups

After 12 weeks of structured exercise based on the SCI International Scientific Guidelines, the intervention group showed a significant improvement in functional independence (Table 2). The average change was 6.75 ± 6.79 points ($p = 0.018$, paired t-test). The mean SCIM-III score increased from 79.25 ± 19.6 at baseline to 86.0 ± 17.8 post-intervention ($p = 0.018$), with a large effect size (Cohen's $d = 0.84$). In contrast, the control group displayed a negligible change in SCIM-III scores (56.38 ± 24.5 to 56.88 ± 23.73; $p = 0.848$). Which was not statistically significant (**Table 2**).

The observed improvement represents a moderate functional gain; however, the clinical significance of this change should be interpreted cautiously due to the small sample size and lack of an established MCID for SCIM-III.

Between-group comparisons

Between-group comparisons confirmed that post-intervention SCIM-III scores were significantly higher in the intervention group than in the controls (86.0 ± 17.8 vs. 56.88 ± 23.73; $p = 0.007$). When analyzing the mean change (delta) in SCIM-III, the intervention group improved by 6.75 ± 6.79 points compared to 0.5 ± 7.09 in the control group ($p = 0.014$). These results demonstrate a statistically greater improvement in SCIM-III scores in the intervention group (Table 2). While these findings are directionally consistent with previous studies, differences in intervention intensity and outcome measures limit direct comparison.

Domain-specific analyses showed that most progress was observed in self-care tasks, followed by improvements in mobility, though to a lesser extent. Scores for respiratory and sphincter function showed no improvement, as expected, since nearly all participants had become independent in these tasks at entry. Some participants felt that useful changes had occurred in their daily lives, such as easier transfers and absence of shoulder pain, especially after completing week three of training.

Safety outcomes and adherence

The program had good tolerance of the study, and the rate of compliance was high at 86.6%. There were no serious events of autonomic dysreflexia, syncope, or severe hypotensive episodes. Two subjects experienced temporary musculoskeletal pain during exercise, which remitted spontaneously. Physiological monitoring remained within safe limits: heart rate increased appropriately from 72 to 95 bpm at rest to 100 to 140 bpm post-exercise, oxygen saturation stayed between 96 and 99%, Borg scale ratings indicated light exertion (10 to 11), and pain levels were mild (WBS 0 to 4).

DISCUSSION

This study found that most participants had incomplete injuries, which reflects the typical outpatient population in Indonesia, where individuals with incomplete SCI are more likely to seek follow-up care after hospital discharge. Moreover, the present findings highlight that even in chronic SCI, structured exercise can yield meaningful improvements in functional independence. However, it should be noted that improvements in metabolic, cardiopulmonary capacity, neuromusculoskeletal performance, and psychology were not directly measured in this study, and therefore, the broad functional recovery claimed in these domains should be interpreted cautiously.[6,8] The observed improvements in strength and endurance are expected to translate into functional outcomes (e.g., transfers, wheelchair mobility, self-care), consistent with previous studies.[15-19] Moreover, previous studies reported that a combined program of fitness and strengthening exercises improved independence in activities of daily living among individuals with SCI, regardless of the level of injury.[20-22]

The group of participants included mostly young adults, which also matches with other studies showing that younger people with SCI tend to recover more function because they have better physical reserves.[21] Trauma accounted for

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Table 1. Baseline characteristics of participants in intervention and control groups

Characteristic	Total (n= 16) Mean±SD or n (%)	Intervention Group (n= 8) Mean±SD or n (%)	Control Group (n=8) Mean±SD or n (%)	*P*-value (Normality test)	*P*-value (Homogeneity test)
Age, years	33.06±12.9	30.50±13.4	35.63±12.7	0.049	0.206[₹]
Gender				0.000	1.000[€]
Female	10 (62.5%)	5 (62.5%)	5 (62.5%)		
Male	6 (37.5%)	3 (37.5%)	3 (37.5%)		
Marital status				0.002	0.272[Ɛ]
Married	7 (43.8%)	4 (50.0%)	3 (37.5%)		
Single	6 (37.5%)	4 (50.0%)	2 (25.0%)		
Divorced	3 (18.8%)	0 (0.0%)	3 (37.5%)		
Education				0.004	0.273[Ɛ]
Elementary school	1 (6.3%)	0 (0%)	1 (12.5%)		
Junior high school	2 (12.5%)	0 (0%)	2 (25%)		
Senior high school	6 (37.5%)	4 (50%)	2 (25%)		
Diploma/Bachelor	7 (43.8%)	4 (50%)	3 (37.5%)		
Medical history				0.000	1.000[€]
None	15 (93.8%)	7 (87.5%)	8 (100%)		
Present (HT/DM/Smoking)	1 (6.3%)	1 (12.5%)	0 (0%)		
AIS classification				0.000	0.083[Ɛ]
A	2 (12.5%)	0 (0%)	2 (25%)		
B	1 (6.3%)	0 (0%)	1 (12.5%)		
C	2 (12.5%)	1 (12.5%)	1 (12.5%)		
D	11 (68.8%)	7 (87.5%)	4 (50%)		
Etiology				0.000	0.608[€]
Traumatic	10 (62.5%)	4 (50.0%)	6 (75.0%)		
Non-traumatic	6 (37.5%)	4 (50.0%)	2 (25.0%)		
Barthel index	80±17.98	87.5±11.3	72.5±20.9	0.017	0.183[₹]
HDRS	5.06±2.26	4.88 ± 2.03	5.25±2.6	0.034	0.914[₹]
MoCA-Ina	29.0±1.23	29.38±0.744	28.75±1.58	0.001	0.571[₹]
SCIM III (SR) baseline	67.81±24.46	79.2±19.6	56.38±24.48	0.127	0.058[†]

[†], independent-sample t test; [€],Fisher's exact test; [Ɛ],Spearman test; [₹],Mann–Whitney test.
DM, Diabetic Mellitus; HDRS, Hamilton Depression Rating Scale; HT, Hypertension; MoCA-Ina, Montreal Cognitive Assessment Indonesian version; n, frequency; SCIM III (SR), Spinal Cord Independence Measure self-report; SD, standard deviation.

Table 2. Comparison of mean SCIM-III (SR) scores before and after 12 weeks of therapy between the intervention and control groups

SCIM III score (SR)	Pre-treatment Mean±SD	Post-treatment Mean±SD	Change (Δ) Mean±SD	*P*-value	Effect size	*P*-value	Effect size
Intervention group	79.25±19.6	86.00±17.8	6.75±6.79	0.018[‡]	0.84	0.014[₹]	0.90
Control group	56.38±24.48	56.88±23.73	0.5±7.09	0.848[†]	0.07		

[†], Paired t-test; ann-Whitney test; [‡], Wilcoxon signed-rank test; [₹], Mann–Whitney test. SCIM III (SR), Spinal Cord Independence Measure self-report; SD, standard deviation.

most cases of SCI in this study (62.5%), consistent with global trends.[23] The mean HDRS score indicated mild depressive symptoms (5.06 ± 2.26). Marital status, a factor closely tied to psychological health and relationship stability, showed no group differences, despite prior evidence of higher divorce rates in individuals with SCI compared with the general population.[24] These reports indicate that individuals with SCI are at increased risk of cognitive impairment, particularly in processing speed, attention, memory, and executive function.[25] In contrast, the present study found preserved cognitive function, as reflected by comparable MoCA-INA scores across groups.

After the 12-week exercise program based on international guidelines for adults with SCI, the intervention group showed significant improvements in functional independence. The improvement in SCIM-III scores was statistically significant and practically relevant, with a mean increase of 6.75 ± 6.79 points. Participants subjectively reported reduced shoulder pain and greater ease during daily activities. These findings provide evidence that guideline-based rehabilitation, when adjusted for cultural differences, is doable and helpful in Indonesia. This finding is consistent with previous studies reporting that exercise enhances psychological well-being in individuals with SCI, including reductions in pain and depressive symptoms.[25] Such improvements are integral to quality of life and therefore particularly relevant when evaluating individuals living with chronic SCI.[8,26,27]

Looking at specific areas of the SCIM-III assessment, self-care improved the most, while breathing and bladder/bowel control stayed the same. This lines up with existing evidence that strength and cardio exercise have little impact on these systems once a person is already independent in those areas.[28,29] Gains in mobility were small but important, which is that structured mobility training leads to gradual improvements in movement and transfers.[30,31]

Comparing with other training modalities provides important context. Progressive resistance and endurance (PRE) training enhances ADL performance, while circuit resistance programs improve aerobic capacity, reduce pain, and increase muscle strength.[22] By comparison, more complex treatments like Activity-Based Therapy (ABT), which incorporates locomotor training and Functional Electrical Stimulation (FES), have more significantly improved motor scales and walking ability than this intervention has.[32] While these findings are directionally consistent with previous studies, differences in intervention intensity and outcome measures limit direct comparison.

These observations are consistent with previous studies[13,33], indicating that exercise increases neural restitution after spinal cord injury by means of molecular and systemic pathways. Enhancement of neurotrophin levels by exercise increases neuronal survival, differentiation, and development due to cell and molecular plasticity, especially through synapsin-1 expression and CREB, MAPK, and PI3K pathways. Simultaneously, it triggers the expression of IGF-1 and VEGF, thereby facilitating angiogenesis, ensuring sufficient nutritional supply, and initiating axonal sprouting and expression of neural growth factors in muscles, sera, and peripheral nerves.[34,35] Moreover, exercise maintains systemic homeostasis and triggers an adaptational response, especially within the cardiovascular system, alongside other target tissues, as a systemic phenomenon.[36,37] On this clinical platform, considerable improvement occurs regarding maximum strength, local muscular endurance, power, and voluntary isometric contraction, especially within SCI subjects.[38]

Notably, the compliance rate of this exercise protocol was high (86,6%), and there were no severe adverse effects. Thus, this indicates that it is feasible and safe to implement guidelines for exercising communities and homes, thereby counteracting concerns that people may not adhere to exercising these populations. Findings of this study propose that guidelines for exercising should be integrated into rehabilitation, as exercise programs are underutilized in Indonesia.

There were some limitations to this research. Being limited by sample size and based on one center, generalizability is low. Also, though providing enough time to notice changes, this study could not explore the sustainability of improvements that had been achieved by the group. Additionally, the only tool used, SCIM-III, didn't express other equally or more valuable aspects, such as quality of life, cardiovascular health, or cognitive abilities, for instance. Studies like this one could be improved by having more than one center and following up on research participants for a longer period of time, and could involve more methods, including advanced ones like robotic and FES, potentially providing more gains as well.

CONCLUSION

In summary, the physical exercise program of 12 weeks, developed on the principles of the Indonesian version of the International SCI Exercise Guidelines, significantly improved functional independence in individuals with chronic spinal cord injuries. Participants showed meaningful progress in their mobility, demonstrating that a combination of cardiovascular and strength exercises can have substantial positive effects on functional recovery. The program was safe, easily followed, and could be effectively incorporated into physical rehabilitation.

These findings suggest that individuals with long-term SCI can still achieve functional improvements when provided with exercise programs grounded in clear, structured guidelines. Moreover, this study supports the integration of these guidelines as a standard part of rehabilitation treatment in Indonesia. The results also pave the way for larger-scale studies across multiple sites, with broader participant inclusion and extended follow-up periods, to further evaluate the long-term benefits of such exercise interventions.

ETHICAL CONSIDERATION

The study protocol was reviewed and approved by the Health Research Ethics Committee, Faculty of Medicine, Universitas Airlangga, Indonesia, and Dr. Soetomo General Academic Hospital (Approval No. 0703/KEPK/VII/2023). Written informed consent was obtained from all participants before enrollment.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

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AUTHOR CONTRIBUTIONS

All authors (NH, MKK, LA, NS, IN, and DP) fully participated in every phase of the study, proposal and conceptualization, funding acquisition, data collection, statistical analysis, analysis and discussion of results, and drafting of the final report.

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