IMPACT OF ACTIVE REHABILITATION ON WHEELCHAIR DISTANCE IN MEN WITH SPINAL CORD INJURY AT THE CERVICAL OR THORACIC LEVELS

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Abstract

The aim of the study was to evaluate the effect of Active Rehabilitation (AR) on wheelchair distance in men with spinal cord injury (SCI) at the cervical or thoracic levels.
The research group consisted of 30 men with cervical or thoracic SCI. All the participants completed the "1st level" rehabilitation camp in Spała (12 days). A modified Cooper test was used twice: the day before and the day after the AR camp. AR had increased the distance covered in a wheelchair in men with thoracic (18%) and cervical (29%) SCI. The percentage of change in the Cooper test result due to AR has a statistically significant dependency on the degree of impairment of spinal cord function according to the ASIA scale (parametric test: p=0.0131, nonparametric test p=0.0018). The level of SCI does not significantly differentiate this variable (parametric test: p=0.3418, nonparametric test p=0.0673). Contrary to expectations, men with SCI at cervical level improved more, which suggests that AR is a valuable therapeutic component in the rehabilitation of patients with SCI. The wheelchair distance improvement due to AR depends more on the degree of impairment of the spinal cord function than on the level of the SCI itself.

***Keywords**: Active Rehabilitation, spinal cord injury, physical capacity.*

Introduction

Spinal cord injury (SCI) is associated with damage to the spinal cord, which results in disruption of motor, sensory and autonomous functions. Literature indicates that SCI is about 5-6 times more common in the male population in European and North American countries and 8-10 times in African countries (Dietz & Curt, 2006; Olasode et al., 2006; Hagen, 2012). The most common type of spinal cord injury occurs in the thoracic and lower cervical regions (C5-C8). Moreover, research shows that incomplete SCI occurred twice as often as complete injury, and 3/5 cases were patients with paraplegia (Chamberlain, 2017).

The concept of Active Rehabilitation (AR) was initiated in Sweden in 1976. It is a specific rehabilitation program for patients with SCI based on cooperation with the community of the injured person. The main goal of the AR is to improve the skills necessary to perform everyday activities and to improve self-esteem. This is achieved through motivation, inspiration and, above all, by sharing the knowledge. It is possible through cooperation with more experienced and active people with SCI who act as instructors and mentors. AR is dedicated primarily to patients with SCI who are starting to adapt to a new life situation or those more experienced who want to further develop the acquired skills. Divanoglou and Georgiou (Divanoglou & Georgiou, 2017) report that currently, key aspects of AR are used in the rehabilitation of people with SCI in more than 20 countries in Europe, Asia and Africa. The main AR components are: peer mentors, non-disabled assistants, focusing on Activities of Daily Living (ADL) and wheelchair skills training, sports and recreational activities, education, training environment, admission criteria, setting goals and final assessment, training of peer mentors, duration of the AR camps (Divanoglou et al., 2017). For this purpose, specially organized camps of the AR are used. They fulfill different functions depending on the phase at which the group of patients is. Some of them are dedicated to newly injured individuals, while others to more experienced patients who want to improve so far trained functioning skills (Divanoglou et al., 2017). AR training camps provide intensive, goal-oriented, group, tailored training and peer support opportunities for people with SCI at various stages of rehabilitation (Divanoglou & Georgiou, 2017; Divanoglou et al., 20175).

Physical capacity (PC) can be defined as the body's capacity to perform a certain level of physical activity. This broadly understood parameter includes the following components: cardiovascular, muscle and respiratory system (Yanci 2015). A low level of PC can also be closely related to disability, which is defined as the inability of a given individual to perform certain tasks and social roles (Boyles, 2008). Low levels of PC can result in many health consequences, which in turn can reduce the patient's quality of life (Noreau & Shephard, 1995). Scientific literature shows that there is a correlation between low PC levels and reduced muscle strength, coordination and endurance in people with mobility impairments (Haga, 2008). It also results in weakening of the muscles of the upper limbs, stabilization of the torso and grip strength (Haga, 2008). Reducing this parameter also results in an increased risk of circulatory and respiratory diseases, obesity and even diabetes (Haga, 2008; Cairney et al. 2007; Andersen et al., 2006; Gutin et al., 2005). There are scientific reports indicating that low PC levels can result in a reduction in bone mass (Hallal et al., 2006). This parameter is not only crucial for maintaining proper physical health, but is also important in the area of the patient's mental health. Research shows that physical activity significantly improves the well-being of SCI patients (Bragg & Pritchard-Wiart, 2019).

The aim of the study was to evaluate the effect of AR on wheelchair distance, measured by the modified Cooper test, in men with SCI at the cervical or thoracic levels. The authors of this manuscript put the following hypothesis: AR will increase the examined parameter in both experimental groups.

Methods

Participants

The study group consisted of 30 men with SCI in the cervical or thoracic levels. Each participant was using an active wheelchair. In order to improve physical fitness, the patients participated in rehabilitation treatment organized by the Active Rehabilitation Foundation. All the patients participating in this research completed the "1st level" camp in Spała of 12 days' duration. For the purposes of comparative assessment, the patients were divided according to the level of SCI and the degree of sensory and motor impairment of the spinal cord. Four research groups (C I, C II, T I, T II) were created based on level of the SCI (Table 1). Four research groups were created based on spinal cord dysfunctions determined using the International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI), published by the American Spinal Injury Association (ASIA) (16) (Table 2). ASIA is based on neurological responses, tactile sensations and pricks tested in every dermatome and muscle strength that control key movements on both sides of the body (American Spinal Injury Association & ISCOS; Teufack et al., 2021). Muscle strength was rated on a scale of 0-5 (Harvey, 2008). All patients suffered from spinal cord injury. No other specific clinical forms were noted in the studied groups. The research was approved by the independent Bioethics Committee at the Medical University of Poznań No. 154/18.

Table 1. Characteristics of research groups in terms of numbers, age and level of spinal cord injury.

Spinal cord level	Level of injury	SCI segments	Age range in years	Number of men	
				N	%
Cervical	C I	C_{4-5}	20-36	9	30.0
	C II	C_6-T_1	22-31	7	23.3
Thoracic	T I	T $_{4-6}$	23-29	6	20.0
	T II	T_7-L_1	20-33	8	26.7

Table 2. Neurological classification of the studied groups using the ASIA Impairment Scale - numbers at specific levels of spinal cord injury.

Spinal cord level	A (16.7%)		B (20.0%)		C (46,6%)		D (16.7%)		E (0%)	
	Level of SCI	N	Level of SCI	N	Level of SCI	N	Level of SCI	N	Level of SCI	N
Cervical	C I	0	C I	0	C I	6	C I	3	C I	0
	C II	0	C II	0	C II	5	C II	2	C II	0
Thoracic	T I	2	T I	3	T I	1	T I	0	T I	0
	T II	3	T II	3	T II	2	T II	0	T II	0

SCI- spinal cord injury; A- Complete injury. No motor or sensory function is preserved in the sacral segments S4 or S5; B- Incomplete injury. Sensory but not motor function is preserved below the level of injury, including the sacral segments); C- Motor incomplete. Motor function is preserved below the level of injury, and more than half of muscles tested below the level of injury have a muscle grade less than 3 in the five-degree scale; D- Motor incomplete. Motor function is preserved below the level of injury and at least half of the key muscles below the neurological level have a muscle grade of 3 or more; E- Normal. No motor or sensory deficits, but deficits existed in the past. Muscle strength: grade 0-5 (0- no muscle contraction, 1- muscle flickers, 2- full range of motion, gravity eliminated, 3- Full range of motion, against gravity, 4- Full range of motion against resistance, 5- normal strength).

The Active Rehabilitation

The AR program proposed by the foundation is carried out in 3 stages: information, improvement at camps, and creation of local field groups. The first stage is engaging the patients. The wheelchair using instructors engage people who are in the early period after spinal cord injury in the hospitals and rehabilitation facilities. The trainer is a support and role model for the patient. The trainer is an example showing that despite disability, a person can function perfectly in everyday life. The Active Rehabilitation Camps are the second stage of the rehabilitation process.

The camps are divided into two levels. The first one has more of an introductory character. This type of camp is designed for people who had undergone rehabilitation at hospital. Its main purpose is to teach participants to function in everyday life using a wheelchair. Participation in the first level camp should take place no earlier than 8-9 months after the injury. In the second level (developing) camps, the aim is to improve the skills gained during the first camp and to master the more difficult activities related to the technique of moving in a wheelchair.

All patients taking part in the study had undergone training at the first level camp. All patients had performed the complete set of exercises included in the Active Rehabilitation camp program. Each day consisted of two 1.5-hour blocks of sports activities, one block of wheelchair technique classes, one block of self-service classes and two meetings - one educational and the second of integrational character. Sports activities included 1.5 hours of general fitness exercises using some elements of sports such as swimming, archery, and table tennis. Participants additionally played different sports for 1.5 hours daily (every other day swimming alternately with team games (rugby, basket and floorball). These disciplines shape strength, coordination and general physical fitness.

Measurement methods

In order to examine the physical capacity of men with spinal cord injury, a modified Cooper test was used. Due to the low hardware requirements, it is one of the most popular physical capacity assessment tests. In the scientific literature it is possible to find many variations of this popular fitness test (Booth & Kendall, 2007; Ditunno et al. 1994). In this study, the test was performed in a sports hall. During the test, all participants belonging to a given research group performed the test at the same time. The test execution time was 5 minutes. All patients moving on wheelchairs covered a 10-meter route restricted by bollards. Before the test the patients underwent a 5-minute warm-up. It consisted of performing basic exercises of upper limbs, torso and head to prepare the most important muscle groups. All wheelchairs were of the same type. The result of the test was the distance covered in meters. The Cooper test was performed twice: the day before and the day after the active rehabilitation camp, in two groups of patients (the first group included patients with SCI at the cervical level, the second patients with SCI at the thoracic level). There are scientific reports that field tests (such as Cooper test) are a reliable and repeatable tool for assessing broadly understood physical capacity in relation to wheelchair users (Franklin et al., 1990; Ergun et al., 2008; Molik et al., 2010).

Statistical methods

The data was analysed in the statistical program Statistica version 13. In order to examine the impact of AR on the value of the Cooper test, an analysis of variance with repeated measurements was carried out. In addition, the student's T-test for dependent variables and its non-parametric equivalent Wilcoxon test were used. These tests were used to determine the significance of the difference (POST-PRE) for the value of the Cooper test performed before (PRE) and after (POST) AR. The diversity of the studied variable depending on the level of SCI and depending on the category of spinal cord impairment on ASIA scale was determined using one-dimensional ANOVA variance analysis and its non-parametric equivalent of the Kruskal Wallis test and post-hoc tests with Bonferroni correction included.

Results and discussion

Basic statistical characteristics of the Cooper test values for the pre (performed before AR) and post (after the AR) tests in SCI subjects depending on the level of spinal cord injury (CI, C II, TI, T II) and the category of spinal cord impairment according to the ASIA scale (A, B, C, D) is shown in Table 3.

Table 3. Statistical characteristics of the value of the Cooper test performed before (PRE) and after (POST) Active Rehabilitation in SCI subjects depending on the level of SCI and the category of spinal cord impairment according to the ASIA scale.

Study group	N	PRE [before AR] Distance [m]				POST [after AR] Distance [m]			
		X	SE	-95.0 %	+95.0%	X	SE	-95.0 %	+95.0%
Group of SCI level									
C I	9	172.78	42.02	86.40	259.15	205.00	40.92	120.90	289.10
C II	7	193.57	47.65	95.63	291.51	227.86	46.39	132.49	323.22
T I	6	448.33	51.46	342.55	554.12	509.17	50.11	406.16	612.17
T II	8	527.50	44.57	435.89	619.11	608.75	43.40	519.54	697.96
ASIA scale categories									
A	5	577.00	60.39	452.87	701.13	605.00	74.17	452.54	757.46
B	6	476.67	55.13	363.35	589.98	536.67	67.71	397.49	675.84
C	14	216.43	36.09	142.24	290.61	272.50	44.32	181.39	363.61
D	5	209.00	60.39	84.87	333.13	261.00	74.17	108.54	413.46

AR- Active Rehabilitation; N - sample size; X – mean; SE-standard error.

Realizing the main goal of the study, which was to determine the effect of AR on the physical capacity of men with SCI using a modified Cooper test, analysis of variance was performed for repeated measurements of this test value and the level of spinal cord injury. By following the results of the analysis of variance for repeated measurements, a statistically significant ($p = 0.000001$) difference was observed between the compared research groups distinguished by the level of spinal cord injury (CI, C II, TI, T II) and between measurements before and after AR [R (PRE, POST)]. There was no significant effect of the interaction between repeated measurements and the level of SCI (R * Group) (Table 4).

Table 4. Summary of the results of the variance analysis for repeated measurements for the Cooper test value depending on the level of SCI.

Effect	F	p	η²	Pr
SCI Group	18.966	0.000001**	0.6864	0.999994
R (PRE. POST)	35.973	0.000002**	0.5805	0.999929
Interaction: R x SCI Group	1.958	0.145058	0.1843	0.445587

SCI Group (C I, C II, T I, T II); R (PRE, POST)- repeated measurements of the Cooper test before and after AR; R*Group - interaction between repeated measurements (PRE and POST) and factor SCI Group (C I, C II, T I, T II); η2- partial eta-square; F-Snedecor's F distribution value; p – test probability; Pr- power of the test (α=0.05); **- statistical significance at the level of α ≤ 0.01; *- statistical significance at the level of α ≤ 0.05

This means that the indicated factors act additively on the values of the Cooper test without showing synergy. The change in the value of the Cooper test over time (before and after AR) in the compared groups distinguished by the level of SCI is parallel (lines are parallel) when presented in graphical form (Figure 1). The calculated eta-partial square value (η2) (Table 4) was multiplied by 100% and a measure of the percentage variance of the dependent variable explained by the effect was obtained (G, R, R * Group). The higher the value of η2, the greater the proportion of dependent variable variation is explained by the given effect. The resulting eta-squared values indicate that the factor: group (level of spinal cord injury) explains as much as 68% of the variability of the Cooper test result, and 58% in the measurement (PRE, POST) (Table 4).

To determine which groups, specified by the level of spinal cord injury, differ significantly, one-dimensional analysis of variance and post-hoc tests (least significant difference - LSD) were performed separately for the results of the Cooper test performed before AR and separately for the results of the Cooper test performed after AR. The results of the analyses indicate a significant difference at the level α≤ 0.01 between the following groups C I and T I (p = 0.000004), C I and T II (p = 0.000318), C II and T I (p = 0.000025) and C II and T II (p = 0.001210), as well as the lack of significant differences in the Cooper test value between the C I and C II groups within the cervical spinal cord and the T I and T II groups within the thoracic spinal cord both before and after AR.

The results of the analysis of variance for repeated measurements indicating the difference between the measurements (PRE and POST), i.e. those made before and after AR, were confirmed by the T test (test of mean versus constant reference value) calculated separately for each of the distinguished levels of SCI (Table 5). Due to the high values of the standard deviation (SD) and the small numbers (N) of individual groups, it is possible that the distribution of the tested variable deviated from the normal distribution, therefore a non-parametric test (Wilcoxon test) was also carried out, which however confirmed the results of the t test for dependent variables. For all distinguished SCI levels, the value of the Cooper test performed before AR differs statistically significantly at the level of α≤0.05 from the value of the Cooper test performed after AR (Table 5).

Table 5. Student's t-test values for dependent variables and Wilcoxon test results for the difference (POST-PRE) values of the Cooper test before and after AR, in individual groups distinguished by SCI level.

Variable POST-PRE	N	Mean	SD	T-test		Wilcoxon test	
				t	p	Z	p
C I	9	32.22	23.99	4.029	0.0038*	2.666	0.0077**
C II	7	34.29	14.27	6.358	0.0007**	2.366	0.0180*
T I	6	60.83	51.52	2.892	0.0341*	2.201	0.0277*
T II	8	81.25	74.20	3.097	0.0174*	2.521	0.0117*
C	16	33.13	19.74	6.713	0.0000**	3.516	0.0004**
T	14	72.50	63.99	4.239	0.0009**	3.296	0.0009**

N- number; SD- standard deviation; t- statistics of the T-test; Z- statistics from the Wilcoxon test;

p – test probability; **- statistical significance at the level of α ≤ 0.01; *- statistical significance at the level of α ≤ 0.05.

The next step in examining the impact of the AR program effectiveness on physical capacity as assessed by the Cooper test was to analyse the results obtained, depending on the category of impairment of spinal cord function according to ASIA (ASIA Impairment Scale Grade = AIS).

Following the results of analysis of variance for repeated measurements, statistically significant differentiation (p = 0.000158) was noted between the compared research groups distinguished by ASIA impairment categories (A, B, C, D) and between the measurements R (PRE, POST) performed before and after AR. There was no significant effect of the interaction effect between repeated measurements and the ASIA impairment category (R * Group) (Table 6). The resulting eta-squared values indicate that the factor: Group (category on the Asia scale) explains the variability of the Cooper test result in 53%, and the measurement (PRE, POST) in 47% (Table 6).

Table 6. Summary of variance analysis results for repeated measurements for the Cooper test value depending on the category of spinal cord impairment according to ASIA.

Effect	F	p	η²	Pr
Group (ASIA scale category)	9.8907	0.000158**	0.532980	0.993965
R (PRE, POST)	23.3210	0.000053**	0.472842	0.996366
Interaction: R x Group	0.4501	0.719354	0.049373	0.127848

Group (ASIA scale category: A, B, C, D); R (PRE, POST)- repeated measurement before and after AR; R*Group - interaction between repeated measurements (PRE and POST) and factor Group (ASIA scale category: A, B, C, D); F-Snedecor's F distribution value; p -test probability; η2- partial eta-square; Pr- power of the test (α=0.05); **- statistical significance at the level of α ≤ 0.01; *- statistical significance at the level of α ≤ 0.05.

To find out which groups distinguished according to the category of spinal cord impairment (according to ASIA scale) differ between each other, one-dimensional analysis of variance and post-hoc tests (Least Significant Difference - LSD) were performed separately for the results of the Cooper test performed before AR and separately for the results of the Cooper test after AR. The results of the analyses carried out show a significant differentiation at the level of α≤ 0.01 before the AR program between the following categories (types) A and C (p = 0.000024), A and D (p = 0.000208), B and C (p = 0.000533), B and D (p = 0.003001), and after the AR program only between A and C (p = 0.000694) and A and D (p = 0.002956). Hence, the conclusion that conducting the AR program in men with SCI resulted in a reduction in differentiation among persons distinguished by category of spinal cord impairment according to the ASIA scale.

The results of the analysis of the variance for repeated measurements indicating the difference between the measurements (PRE and POST), i.e. those made before and after the AR, were confirmed by the T test (test of means against a fixed reference value) calculated separately for each of the categories identified on the ASIA scale (Table 7). Due to the high values of the standard deviation (SD) and the small numbers (N) of individual groups, a nonparametric test (Wilcoxon test) was carried out, which also confirmed the results of the t test for dependent variables. For all distinguished categories of spinal cord impairment according to the ASIA scale, the value of the Cooper test performed before AR differs statistically significantly at the level of α≤0.05 from the value of the Cooper test performed after AR (Table 7).

Table 7. Student's t-test values for dependent variables and Wilcoxon test results for the difference (POST-PRE) values of the Cooper test before and after using AR in individual groups distinguished by categories of spinal cord impairment according to the ASIA scale.

Variable POST-PRE	N	Mean	SD	T-test		Wilcoxon test	
				t	p	Z	p
A	5	28.00	11.51	5.439	0.0055**	2.0226	0.0431*
B	6	60.00	18.17	8.090	0.0005**	2.2014	0.0277*
C	14	56.07	69.87	3.003	0.0102**	3.2958	0.0010**
D	5	52.00	19.56	5.945	0.0040**	2.0226	0.0431*

N- number; SD- standard deviation; t- statistics of the T-test; Z- statistics from the Wilcoxon test; p – test probability; **- statistical significance at the level of α ≤ 0.01; *- statistical significance at the level of α ≤ 0.05.

To assess which of the factors examined (level of spinal cord injury or category of spinal cord impairment to a greater extent influences the improvement of the Cooper test result, the parameter being the percentage of Cooper test change due to AR was used and analysed. The analysed variable [(POST- PRE) * 100 / PRE] is the difference in the value of the Cooper test performed before and after the AR (POST-PRE) expressed as a percentage in relation to the value before the AR (PRE). One-dimensional analysis of variance was performed for this variable and the discussed factors: patients with cervical groups SCI (C) and thoracic SCI (T), level of spinal cord injury (CI, C II, Th I, Th II) and categories of spinal cord impairment according to ASIA (A, B, C, D). There was no significant differentiation of this variable between the group with cervical SCI and thoracic SCI, or between groups distinguished by the level of spinal cord injury. The only differentiation was observed due to the category of spinal cord impairment according to the ASIA scale (Table 8).

The use of the LSD test, taking into account the Bonferroni correction, allowed the disclosure of a statistically significant difference at the level α≤0.05 (p = 0.002) only between people with type A and type D dysfunction (Table 9).

Table 8. The results of the analysis of variance for selected factors and the dependent variable being the percentage of the change in the Cooper test result due to the AR.

Study group	Analysis of variance for the variable % change in the Cooper test value						
	N	X	SD	df_1	df_2	F	p
Factor: Group: cervical SCI (C) and thoracic SCI (T)							
C	16	28.98	37.89	1	28	0.935	0.3418
T	14	18.04	20.07				
Factor: level of SCI (C I, C II, T I, T II)							
C I	9	21.09	10.25	3	26	0.739	0.5382
C II	7	39.12	56.89				
T I	6	18.07	21.29				
T II	8	18.01	20.59				
Factor: spinal cord impairment category (A, B, C, D)							
A	5	5.02	2.10	3	26	4.344	0.0131*
B	6	13.54	5.99				
C	14	24.61	10.61				
D	5	53.03	34.76				

N- number; X- mean; SD- standard deviation; df- degrees of freedom; p – test probability; **- statistical significance at the level of α ≤ 0.01; *- statistical significance at the level of α ≤ 0.05.

Table 9. The p-values for the NIR LSD test variable which is a percentage of the change in the Cooper test result as a result of the AR, for individual pairs of categories distinguished by spinal cord impairment according to the ASIA scale.

ASIA scale	P-values for the LSD test			
	A	B	C	D
A		0.3009	0.0249	0.0022*
B	0.3009		0.2294	0.0196
C	0.0249	0.2294		0.0937
D	0.0022*	0.0196	0.0937	

p – test probability; **- statistical significance at the level of α ≤ 0.01; *- statistical significance at the level of α ≤ 0.05 (after taking into account the Bonferroni correction).

Bonferroni correction (for 4 groups we have 6 pairs, i.e. 6 comparisons): for α = 0.05 is p = 0.05/6 = 0.008333; for α = 0.01 is p = 0.01/6 = 0.00166; for α = 0.1 is p = 0.1/6 = 0.016666.

Also in the case of the variable being the percentage change in the Cooper test result as a result of the AR, due to high values of standard deviation (SD) and low numbers (N) in individual groups, nonparametric tests were used. The applied Kruskal Wallis test basically confirmed the results of the analysis of variance, but differentiated the distinguished groups more strongly (Table 10). The difference between the percent of the improvement in the Cooper test value due to the use of AR between patients with cervical SCI and thoracic SCI was significant on the border of the statistical trend (p = 0.0673) in favour of the former, and between people with different categories of the ASIA scale, the difference was highly significant statistically (p = 0.0018). The use of a nonparametric test for multiple comparisons including the Bonferroni correction showed that the difference between persons with type A and type D impairment is statistically significant at the level of α≤0.01 (p = 0.0016) (Table 11).

Table 10. Results of the Kruskal Wallis test for selected factors and variable:
(POST-PRE) * 100 / PRE.

Variable	N	Average rank	H	p
Factor: Group: cervical SCI (C) i thoracic SCI (T)				
C	16	18.25	3.35	0.0673
T	14	12.36		
Factor: level of SCI (C I, C II, T I, T II)				
C I	9	18.50	3.39	0.3351
C II	7	17.93		
T I	6	11.92		
T II	8	12.69		
Factor: spinal cord impairment category (A, B, C, D)				
A	5	3.70	15.04	0.0018**
B	6	12.92		
C	14	17.82		
D	5	23.90		

H - statistics of the Kruskal Wallis test; p – test probability; **- statistical significance at the level of α ≤ 0.01; *- statistical significance at the level of α ≤ 0.05.

Table 11. The p-value for multiple comparisons of the variable (POST-PRE) * 100 / PRE for individual pairs of categories distinguished by spinal cord impairment according to the ASIA scale.

Skala ASIA	P-value for multiple comparisons Independent variable: ASIA scale Test Kruskala-Wallisa: H (3, N= 30) =15.03904 p =.0018			
	A R:3.70	B R:12.91	C R:17.82	D R:23.90
A		0.5029	0.0125	0.0016**
B	0.5029		1.0000	0.2362
C	0.0125	1.0000		1.0000
D	0.0016**	0.2362	1.0000	

R - the average rank of the Kruskal Wallis test; p – test probability; **- statistical significance at the level of α ≤ 0.01; *- statistical significance at the level of α ≤ 0.05 (after taking into account the Bonferroni correction).

Bonferroni correction (for 4 groups we have 6 pairs, i.e. 6 comparisons): for α = 0.05 is p = 0.05/6 = 0.008333; for α = 0.01 is p = 0.01/6 = 0.00166; for α = 0.1 is p = 0.1/6 = 0.016666.

Comparison of the distance (expressed in meters) covered in wheelchairs before (PRE) and after (POST) the AR by men with cervical SCI depending on the segment of the injury is shown in Figure 3. During POST measurements, all participants in the AR improved their results. The highest improvement of results - as much as 167% - was obtained by a man with SCI at C6-T1 level, while the smallest - of 17% - by a participant with SCI at C5-6 level. These people, despite having SCI at the level of close segments, had a different category of impairment of spinal cord function (first - category D, second - category C).

Comparison of before (PRE) and after (POST) the AR of the distance (expressed in meters) covered in wheelchairs by men with thoracic SCI depending on the level of injury is shown in Figure 4. In this group of patients, the observations were similar as in those with cervical SCI. The biggest improvement in the Cooper test result - as much as 67% - was recorded in a man with a SCI at T12-L1 segment with category C impairment in the ASIA scale, and the smallest - of only 2% - in a man with SCI level T10-11 with category A.

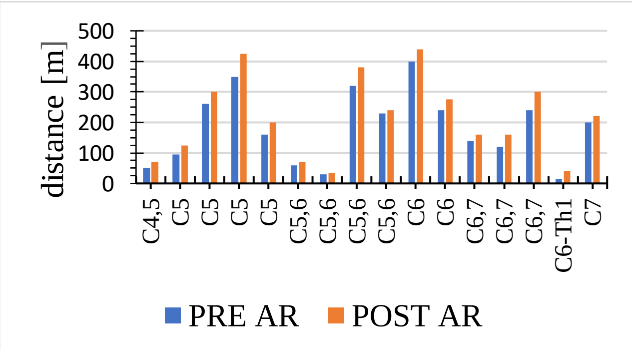

Figure 1. Comparison of distance travelled in wheelchairs in Cooper test performed before (PRE)

and after (POST) Active Rehabilitation (AR) in patients with cervical SCI.

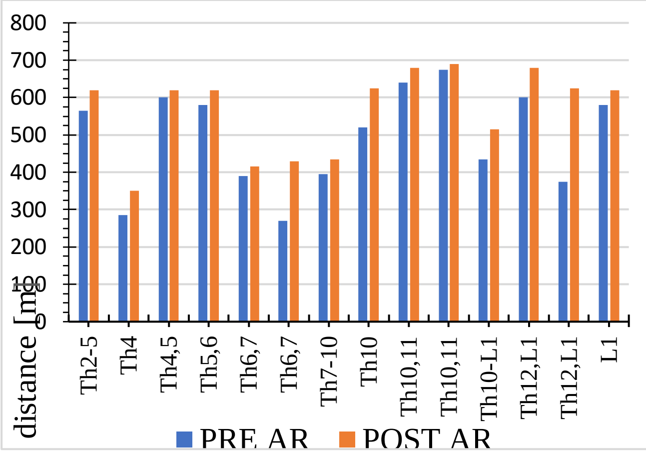

Figure 2. Comparison of distance travelled in wheelchairs in Cooper test performed before (PRE) and after (POST) Active Rehabilitation (AR) in subjects with thoracic SCI.

The collected results indicate that all examined groups of patients with SCI significantly improved wheelchair distance due to AR, which may be related to the improvement of the broadly understood physical capacity (PC). This effect was observed in patients with SCI at the cervical or thoracic level. People with SCI at the thoracic level in the pre (before AR) and post measurements (after AR) covered distances 2.5 times greater than people with cervical SCI. It is probably dependent on the extent of motor dysfunctions resulting from the level of SCI. Schantz et al. (1999) emphasize the differences in movement patterns and individual phases of wheelchair movement by people with SCI at the cervical or thoracic level. The study using an electromyograph showed significant differences in bioelectric activation of shoulder girdle muscles and upper limbs. People with SCI at the thoracic level have functional triceps brachii muscle, unlike patients with cervical SCI. According to the research of Schantz et al. (1999), this muscle plays a significant role in the wheelchair movement pattern. Triceps brachii muscle dysfunction significantly affects the reduced speed of movement in a wheelchair, and consequently the distance covered.
An interesting result of the study is the achievement of a greater improvement in the values of the Cooper test performed after the AR in people with cervical SCI. This group achieved a 29% increase in the measured parameter, while in men with thoracic SCI the improvement was 18%. The difference of percentage fractions is not statistically significant, however, it shows that AR is a therapeutic tool equally effective on wheelchair distance in people with more motor dysfunctions resulting from the level of spinal cord injury.
Another important observation of this research is that the wheelchair distance improvement due to the AR depends more on the degree of impairment of motor functions than on the level of spinal cord injury itself. The analysis showed that people with similar levels of SCI significantly differed in improving the Cooper test results. One of the men with SCI at C6-T1 level, as a result of the AR, improved distance parameter by 167%, while another with C5-C6 SCI only by 17%. However, these individuals had a different category of spinal cord impairment according to the ASIA scale (first participant - category „D", second - category „C"). Similar observations were made among people with thoracic SCI. A man with category C, resulting from SCI at level T12-L1, improved his Cooper test result by 67%, while another man with T10-11 SCI (category „A" on ASIA scale) by only 2%. The results of both parametric (Table 8-9) and non-parametric (Table 10-11) tests show that the percentage of Cooper test change due to AR is significantly different depending on the degree of spinal cord dysfunction according to the ASIA scale. This is probably due to differences in motor deficits defined by the ASIA scale. Patients with incomplete SCI retain some motor functions due to the damaged myelomer (Teufack et al., 2012). Therefore, it can be concluded that the level of injury and degree of impairment should always be included as inseparable data in the case of rehabilitation of SCI patients.
Scientific literature indicates that limiting broadly understood PC in people with various types of motor dysfunctions may have a negative impact on their health (Haga, 2008). In addition to numerous motor consequences, disorders in the area of the respiratory system are also observed. The result is a reduction in various performance related parameters such as: VO2 peak, peak ventilation rate and peak blood lactate concentration (Goosey-Tolfrey & Leicht, 2013; Hol et al., 2007). Scientific research indicates that the higher the level of damage, the lower the values of the parameters described above and vice versa (Molik et al., 2010; Schantz et al., 1999; Goosey-Tolfrey & Leicht, 2013; Hol et al., 2007; Bhambhani, 2002). Consequently, this can lead to deterioration of the patient's health parameters, which in turn can lead to obesity or cardiovascular disease (Haga, 2008). Gendle et al. (2012) believe that the use of various forms of physical activity can positively affect health by reducing the risk of common chronic diseases. It is believed that increasing the level of PC should be a key goal in the rehabilitation of chronically ill people (Bhambhani, 2002). Scientific literature indicates that strength training is the type most frequently used during rehabilitation of patients with SCI (Franz, 2018). This applies both to patients moving in wheelchair and patients with preserved function of walking. Active rehabilitation is aimed primarily to restore the various functions of the patient. In patients with preserved walking function there are applied activities such as swimming or other different kinds of exercises aimed to improve walking activity. It is very important to take into account the individual possibilities of the patient throughout the rehabilitation process. During specific exercises, all available fields should be used (Franz, 2018).
Most scientific articles relate to the subject of SCI are observational studies. There are definitely fewer clinical articles that would evaluate the effectiveness

of the various support programs proposed in relation to various physical, mental and social parameters (Bloemen-Vrencken et al., 2005; Gómara-Toldrà et al. 2014; McColl et al. 2021). Booth and Kendall (2007)`showed superiority of home-based transitional rehabilitation programs considering the multidisciplinary aspect over traditional rehabilitation performed only in a hospital. Authors of this publication emphasized the need to use the environment in which a given patient functions and the involvement of the family in the rehabilitation process. Prabhaka and Thakker (2004) also assessed the effectiveness of rehabilitation at the patient's home. The study involved 546 patients with SCI. The proposed program significantly reduced the number of visits to the hospital, improved the status of rehabilitation and improved the quality of patient care. DiPiro et al. (2016) assessed the efficiency of non-task-specific, voluntary, progressive aerobics exercise training (AET) for patients with partial SCI. A marked improvement in the aerobics area capacity ($p = 0.011$), walking speed ($p = 0.023$), and number of steps per day ($p = 0.025$) has been noted. Harkema, et al. (36) evaluated the efficiency of locomotor training-based rehabilitation on patients with partial SCI. The authors noted statistically significant improvement in the area of balance and walking skills. Also Harness et al. (2008) confirmed that a targeted rehabilitation program benefits patients with SCI. The authors investigated the effectiveness of prolonged, intense exercise on a small research group of 29 participants. A marked improvement ($p = 0.0001$) in the area of motor function measured with the ASIA motor score was noted. It was also proved that long-term rehabilitation improved the strength of the upper body but also positively affected the psyche of the SCI patient (Hicks et al., 2003). The training caused a significant reduction ($p < 0.05$) in the level of pain, stress and depression as a consequence of the injury. In the case of various aforementioned rehabilitation programs for persons with SCI, a positive impact on various parameters of their physical and mental health was noted. In the literature known to the authors, there are no research papers focusing on the PC in patients with SCI using wheelchairs who had gone through the AR camp.

It is possible to restore some functions to some extent in people with central nervous system damage (Wirth et al., 2008). Of course, the level and extent of the damage plays a significant role here and this should be taken into account when planning the therapy. The smallest improvement is characteristic for people with total SCI (Lim & Tow, 2007). The improvement of the clinical status of a patient with damage to the central nervous system is possible thanks to the mechanisms of functional compensation, regenerative processes of the body and plasticity of the nervous system (Lim & Tow, 2007). Curt et al. (2008) conducted a study on 460 acute SCI patients. People with incomplete SCI were characterized with functional and neurological improvement as a result of a 12-month intensive rehabilitation. In patients with overall SCI no improvement in neurological status was noted, while improvement in the function area was observed. Although in both groups of patients there had been noted favourable changes in the conductivity of the spinal cord, those improvements were seen within the function (Wirth et al., 2008; Lim & Tow, 2007; Curt et al., 2008). The results of our research confirm that in the rehabilitation process, not only the level of damage to the spinal cord is important, but also the degree of its impairment. The increase in the distance traveled on wheelchairs concerned both people with thoracic and cervical SCI, which may indicate the importance of compensation mechanisms in the rehabilitation process of patients after SCI.

We are aware of the disadvantages of the study due to the specifics of the study group and the technical difficulties associated with organizing AR camps. Including a control group (for example, people with SCI who do not participate in the AR camp), although very difficult to do, could enrich statistical analysis and allow additional conclusions to be drawn. It would be helpful to increase the number of participants and to use additional measurement methods. In future studies related to the usefulness of the AR for patients with SCI, we plan to use subjective measurement methods assessing the impact of this type of rehabilitation on the quality of life and the degree of everyday activities. An equally interesting project can be the assessment of changes in functional parameters in people with SCI as a result of the AR program.

Conclusion

1. AR increased the distance covered in a wheelchair in men with SCI at both the thoracic and cervical levels. Contrary to expectations, men with cervical SCI improved (29%) more than men with thoracic SCI (18%), which suggests that AR is a valuable therapeutic component in rehabilitation of patients after cervical SCI.
2. The percentage change in the Cooper test in men with SCI participating in the AR program does not significantly depend on the level of SCI, but shows a statistically significant relationship with the degree of impairment of the spinal cord function according to the ASIA scale. The biggest difference was observed between categories A and D. This finding is extremely important in selecting people with SCI for the AR camp or planning any type of rehabilitation and research related to SCI.
3. We believe that the use of a cheap and simple measurement method, the result of which is visible to patients and shows the effects of AR immediately after its completion, will contribute to a better understanding of the need for continuous rehabilitation and will increase the patient's motivation and involvement in its course.

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