**FACTA UNIVERSITATIS**
Series: **Physical Education and Sport**, Vol. 17, No 2, 2019, pp. 397 - 407
https://doi.org/10.22190/FUPES190509035S

**Review article**

# IS PHYSICAL EXERCISE EFFECTIVE FOR IMPROVING $VO_2$max IN PERSONS WITH SCI? A SYSTEMATIC REVIEW

*UDC 796.015.132:616.832*
*796:613*

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**Abstract.** *Maximum Oxygen Consumption ($VO_2$max) is considered to be one of the most relevant indicators of the level of functional ability of the cardiorespiratory system in individuals and athletes. It is an indicator of the functional state, and knowledge of the value of $VO_2$max is of great importance in order to improve the functional form for athletes and recreational exercisers, as well as to properly plan, program and dose activities. The aim of this study was to review the literature in order to determine whether physical exercise can improve $VO_2$max in people with spinal cord injuries. The following electronic databases were used to collect the papers: KoBSON, Google Scholar, MEDLINE, PEDro, DOAJ and Open J Gate. The key words that were used to find the papers are: physical exercise, $VO_2$max, spinal cord injury, adaptation, training, effects, patients, intensity, aerobic, anaerobic, heart rate. Based on inclusive and exclusive criteria, eight papers were selected that met the set criteria. Analyzing the papers, only four papers examined the differences in terms of the intensity of the exercise with the goal of finding out which intensity is suitable for improving the $VO_2$max value. They have found that the $VO_2$max value can be enhanced by physical exercise of increased intensity (HIIT) relative to physical exercise of moderate intensity (LI). Considering the high level of heterogeneity of the scientific papers, the sample of participants, measuring instruments, and experimental research, the conclusions should be taken with caution.*

**Key words**: *Spinal Cord Injuries, Physical Exercise, Therapy, Physical Fitness, Health*

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Received May 09, 2019/ Accepted June 30, 2019
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## INTRODUCTION

Spinal cord injuries (SCI) represent the physiological, psychological and financial challenge to an individual (Anneken, Doose, Hirschfeld, Scheuer & Thietje, 2010). Data show that the incidence of SCI in the United States has increased to approximately 12,500 cases per year (Ravenscroft, Ahmed & Burnside, 2000; Bernhard, Gries, Kremer, Martin-Villalba & Böttiger 2005; Ginis, Hicks, Latimer, Warburton, Bourne, Distor, Goodwin, Hayes, McCartney, Mcllraith, Pomerleau, Smith, Stone & Wolfe, 2011). Serious consequence of SCI lead to damage to motor centers that are responsible for movement (dysfunction of motor functioning), leading to a sedentary lifestyle and an increased risk of chronic illness (Astorino, DeRevere, Anderson, Kellog, Holstrom, Ring & Ghaseb, 2018).

Reduced physical activity leads to a decrease in functional abilities and the ability to work (Kroll, Kehn, Ho & Groah, 2007). The reason for this is that daily activities in people with SCI are not sufficiently intense to prevent a decrease in physical fitness (Hetz, Latimer, Buchhols & Ginis, 2009).

As a result, complex multifactorial health effects occur, particularly those associated with endocrine and metabolic disorders (diabetes mellitus, dyslipidemia, obesity), which have been worryingly developing over the past several years, thereby increasing the risk of cardiovascular morbidity and mortality in persons with SCI (Escalona, Brosseau, Vermette, Comtois, Duclos, Aubertin-Leheudre & Gagnon, 2018). SCI is the cause of paralysis of the lower extremities, which limits the ability of a man to walk, often resulting in the use of wheelchairs (Kressler, Wymer & Domingo, 2018).

Unfortunately, wheelchairs and transfers exert great demands on bones, joints and soft tissues of the upper extremities (Boninger, Koontz, Sisto, Dyson-Hudson, Chang, Price & Cooper, 2005). Physiological decline in abilities, including bone and muscle atrophy, poor cardiac function of the myocardium, and a general decline in physical fitness, often appear in people with SCI who use a wheelchair (Bucholz, McGillivray & Pencharz, 2003). In order to adequately cope with the efforts of everyday activities and prevent the emergence of long-term, secondary health problems, it is necessary to maintain an optimal level of physical fitness for people with SCI (Fekete & Rauch, 2012).

$VO_2$max is considered one of the most relevant indicators of the degree of functional ability of the cardiorespiratory system in individuals and athletes (Myers, Kaminsky, Lima, Chistle, Ashley & Arena, 2017). $VO_2$max is expressed in liters/min as the absolute value, and in milliliters/kg/min as the relative value. $VO_2$max value is usually used as an indicator of physical fitness and is considered the best indicator of aerobic fitness (Nabi, Rafiq & Qayoom, 2015). Aerobic exercise in people with SCI is perfect for improving health and quality of life (Talyor, Picard & Widrick, 2011), because it is an activity that is stronger than the rhythm of normal daily activities and much less than the greatest possible strain. The effects of physical exercise as a preventive measure affect the optimal health status of the individual, which indirectly improves the exercise and its efficiency (Kostić, 2017). The potential role of exercise in improving the quality of life of people with SCI can not be underestimated. Studies in the last ten years have shown positive effects of regular exercise on a wide range of subjective outcomes (pain, depression, quality of life) among several different types of disorders, including people with osteoarthritis, fibromyalgia, and HIV/AIDS (Hicks, Martin, Ditor, Latimer, Craven, Bugaresti & McCartney, 2003). Increased physical activity is often identified as a key public health target and a leading health indicator, and research has shown that after returning to the community after rehabilitation, people with SCI will probably be less physically active than the working-age population (Kehn & Kroll, 2009). It was found that individuals with SCI individually have a lower $VO_2$max level, poor cardiac performance, and a lower value of maximum heart rate (HRmax%) (Kehn & Kroll, 2009).

That is why physical exercise in SCI patients is important in order to maintain the level of physical abilities necessary for normal functioning in everyday life. Given these facts, it is important to emphasize that the increase in physical activity can play an important role in reducing the cardiovascular risks of the disease in people with SCI. The aim of this study was to review the literature to determine whether physical exercise can contribute to the improvement of $VO_2$max in people with SCI.

## METHODS

### Search strategy and selection of scientific papers

The following electronic databases were used to collect the papers: KoBSON, Google Scholar, MEDLINE, PEDro, DOAJ and Open J Gate. The key words that were used to find the papers are: physical exercise, $VO_2$max, spinal cord injury, adaptation, training, effects, patients, intensity, aerobic, anaerobic, heart rate. The range of the time intervalwas from 2000 to 2018.

### Inclusion criteria

The inclusion criteria were that the paper dealt with the problem of $VO_2$max, that the participants suffered from SCI, that the training plan and program lasted for at least two weeks, and that the studies were experimental.

### Exclusion criteria

The exclusion criteria referred to the rejection of papers: (1) because they did not deal with the problem of physical exercise effects on the improvement of $VO_2$max, (2) persons who did not have SCI, (3) the training program lasted less than two weeks, and (4) duplicates and review papers.

## RESULTS

In total, 2395 papers were identified. Based on the first review, a total of 1963 papers were rejected. The papers were rejected on the basis of titles, abstracts, papers published before 2000, review papers, inappropriate samples of participants (working age population, population with other types of disability), and participants not suffering from SCI. After eliminating 1963 papers, 28 papers were accepted for analysis. Of the 28 papers, 18 papers were rejected because they did not focus on $VO_2$max, were written in another language, or were poster presentations. In the end, eight papers were accepted that satisfied the set of inclusion criteria, because the participants had SCI and because an exercise program was used to test the physiological variable $VO_2$max.

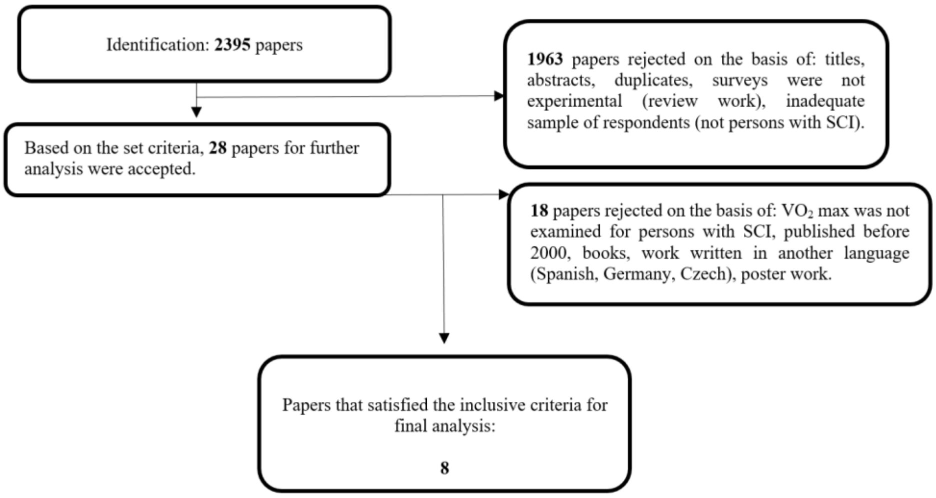


**Fig. 1** Show collection of papers

**Table 1** Summary of the characteristics of all studies that satisfy the inclusion criterion

| The first author and year | Groups (K/E) | Respondents (number, sex, age, type of injuries) | Type of activity | Program duration | Testing | Results |
|---|---|---|---|---|---|---|
| Bougenot et al. (2003) | One group of respondents | M (n=7) age 35±13 with SCI (from T6 to L5) | Maximum progressive test with wheelchair ergometer | 6 weeks | VEN ($V_E$ 1/min), RS (b/min), DV ($V_t$, l), $VO_2$ max (ml/min; ml/min/kg), $CO_2$ ($VCO_2$ ml/ min), HRmax (b/min), MTP, PO, TPW | ↑* $VO_2$ max, $O_{2pt}$ VEN, $VO_{2\ VT}$ $VE_{VT}$, $O_{2PVT}$, MTP, PO, TPW ↓* HRmax VEN |
| Groot et al. (2003) | One group of respondents | M/W (n=6) age 20-54±13 with SCI (from C5 to L1) | Training LI, HIT | 8 weeks | $VO_2$ max (l/min; ml/kg/min), PO, (Watts), HRmax (b/min), IS, LP (mmol/L), (HDL), (LDL), TR | ↑* $VO_2$ max ↑* $PO^{max}$ |
| Widman et al. (2006) | One group of respondents | M/W (n=8) age 15.5±0.6 with SCI (SB) | Activities using the ergometer for the upper part of the body with video games | 16 weeks | $VO_2$ (l/min; ml/kg/min), $PO_{max}$ (watts), AI, $HR_{max}$ (b/min), OZN, ZK | ↑* $VO_2$ max ↑* HRmax |

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|---|---|---|---|---|---|---|
| Lindberg et al. (2012) | One group of respondents | M/W (n=13) age 22-67 with SCI from T5 to L1) | Activities with the use of a sitting ergometer with double pulling | 10 weeks | $VO_2$ l/min,<br>$VO_2$ ml/kg/min,<br>VE ( l/min),<br>RK ($VO_2$/$CO_2$),<br>HRmax (b/min),<br>LA (mmol/l),<br>W | ↑* $VO_2$ max<br>↑* VEN<br>↑* LA MAX<br><br>↓* VEN<br>↓* LA SUBMAX |
| Astorino & Thum (2016) | One group of respondents | M/W (n=9) age 27-57± 10.5 with SCI: TR, PR (from C5 to T9) | The training program of moderate intensity as well as the training of the sprinting interval (SIT) (ergometer) | 2-3 weeks | $VO_2$ max (l/min),<br>HRmax (b/min),<br>LA (mmol/l) | ↑*$VO_2$ max<br>↑*HRmax |
| Harnish et al. (2016) | One group of respondents | M (n=1) age 42 with SCI (from C8 to T1) | HIT training program with a manual ergometer | 12 weeks | BM %, FM kg,<br>FFM kg,<br>$VO_2$ max (ml/min$^1$),<br>($W_{max}$), $TT_{30}$ (W), $TT_{30}$ KL (mM), ZT-HRmax (zt 1: <128 bmp, zt 2: 128-152 bmp, zt 3: > 153 bmp) | ↑* $VO_2$ max<br>↑* P (W) |
| Brazg et al. (2017) | One group of respondents | M/W (n = 15) age 49±8.1, with SCI (from C1 to T10) | Intensive and moderate locomotor training program (LT) | 4-6 weeks | BHKD, SSS, FS, BSB,<br>HR (HRmax),<br>$VO_2$max (ml/kg/min), $O_2$ (ml/kg/min) | ↑* $VO_2$ max<br>↑* HRmax |
| Skučas (2018) | One experimental and one control group | M (n=12) age 19-32 with SCI: PA | A training program for strength and endurance | 8 weeks | HRmax (b/min),<br>$VO_2$max,<br>PZ (SF 36),<br>ISR (N), SRP (1RM) | EX: ↑* P (W)<br>↑* $VO_2$max<br>↑* PZ<br>KO: 0 |

*Legend*: VEN - ventilation, RS - respiratory frequency, DV - breathing volume, $VO_2$max - maximal oxygen consumption, $CO_2$ / $VCO_2$ - carbon dioxide production, HRmax - maximum heart rate, $O_{2p}$ - oxygen pulse, $VO_{2VT}$ - ventilation threshold, MTP - maximum tolerant power, TPW - total physical work, PO - output power, W - power, LP - lipoprotein, HDL - high density lipoprotein, LDL - low density lipoprotein, IS - insulin sensitivity, TR - triglycerides, $PO_{max}$ - maximum output power, AI - aerobic endurance, OZN - an estimate of the observed effort, ZK - user satisfaction, RK - respiratory rate, LA - lactate level, BM - body fat, FM fat mass, FFM - fat free mass, MAX - maximal intensity, SUBMAX - submaximal intensity, ZT - training zone, PZ - psychic health, SF 36 - questionnaire, ISR - isometric force, SRP - shoulder strength, 1RM - one maximum repetition, BHKD - short distance walking speed, SSS - self speed, FS- the fastest possible speed, BSB - Berger scale balance, M - men, W - women, SCI - spinal cord injury, TR - tetra plegia, PA – paraplegia, SB - spina bifida, C - cervical spine, T - toracal spine, LI - moderate intensity, HIT - high interval training, LT - lokomotor training, ↑* - significant improvement, ↓*- improvement not significant, 0 - no improvement, EX - experimental group, CO - control group.

**Characteristics of the studies**

Based on the set of inclusion and exclusion criteria, Table 1 shows the studies that met the set criteria. A total of eight studies were presented in chronological order from the most recent to the oldest. The total number of participants is 71, of which 17 women and 42 men. In two studies, the participants were men (Bouget et al., 2003; Harnish et al., 2016), and five studies included participants of both sexes (DeGroot et al., 2003; Widman et al., 2006; Lindberg et al., 2012; Astorino & Thum, 2016; Brazg et al., 2017). On the other hand, as far as the research design is concerned, only one study had a control and experimental group of participants (Skučas, 2018), while the other studies did not have (Bougenot et al., 2003; DeGroot et al., 2003; Widman et al., 2006; Lindberg et al., 2012; Astorino & Thum, 2016; Harnish et al., 2016; Brazg et al., 2017). As for the duration of the experimental program, the studies differed in terms of the duration of the training. In one study (Astorino & Thum, 2016), the training program lasted for at least two to three weeks, while in another study (Widman et al., 2016), the training program lasted for a total of 16 weeks.

## DISCUSSION

Based on the results of the research, eight studies were presented that met the inclusion criteria. In the analyzed studies, there is a difference in the number of participants, where the most took part in the study of Brazg et al. (2017) (n=15), while the fewest participants took part in the study of Harnish et al. (2016) (n=1). Most of the studies used the ergometer as a measuring instrument for people with SCI (Bougenot et al., 2003; DeGroot et al., 2003; Widman et al., 2006; Lindberg et al., 2012; Astorino & Thum, 2016; Harnish et al., 2016), while the remaining two studies did not have a test protocol which included the ergometer (Brazg et al., 2017; Skučas, 2018). The minimum duration of the training program was detected in Widman et al. (2006), 20 min, while the longer duration of the training program was detected in Skučas (2018), 2h. As for the frequency of the training program, most studies organized a training program three times a week (Bougenot et al., 2003; DeGroot et al., 2003; Widman et al., 2006; Lindberg et al., 2012; Astorino & Thum, 2016; Harnish et al., 2016; Brazg et al., 2017), while in the study of Skučas (2018) the frequency of training was four times a week.

Analyzing the studies, the experimental research program ranged from study to study. In the research of Bougenot et al. (2003), the participants practiced for 45 min on a wheelchair ergometer. The sessions consisted of nine consecutive activities lasting 5 min. Each exercise consisted of a 4 min period of moderate intensity (basic level), followed by a period of 1 min of intense exercise. The intensity of each training period was determined to increase up to 80% HRmax. In the research of DeGoot et al. (2003) the participants were randomly divided into two groups: a moderate intensity group (LI) and high intensity group (HIT). Training programs for both groups of intensity consisted of 1h interval group training. Different intensities ranged from 70 to 80% HRmax in the HIT group and from 40 to 50% HRmax in the LI group.

In the research of Vidman et al. (2006), the design of the research was specific, due to the degree of damage the participants, because they could not participate in any sporting activities. For this reason, the research was carried out in the first part in laboratory conditions with the use of an ergometer with handles for the upper part of the body and a monitor that was attached to the ergometer for video games (GameCycle). For $VO_2max$ assessment, the participants rotated the manual ergometer at a constant speed of 70 rpm/min for 2 min at 0 W resistance, then the resistance was increased in mode at a speed of 10 W/min. The study used the Borga scale from 6 to 20 whose value was recorded every minute. To test the correlation between arm strength and aerobic fitness, the initial power values were recorded using a dynamometer. After laboratory testing, each participant was sent a home-made with a GameCycle ergometer. The participants spent 20 min playing games over an ergometer, three times a week. The participants carried a pulse meter for HRmax monitoring whenever they started the game.

In the research of Lindberg et al. (2012) the experimental program included training three times a week for a duration of 50 min, which included heating, interval variations of 6-7 min and finally relaxation. Interval periods varied, from 15s to 1 min. Intensity of interval training was determined to correspond to values of 70 to 100% HRmax.

In the study of Astorino & Thum (2016), the training program included two to three weeks training with a 25 min duration of training for the sprint interval and 30 min for moderate intensity training. $VO_2max$ was evaluated during progressive work on a manual ergometer. The continuous exercise consisted of 25 min of starting the arm at 45% W, while the HIT consisted of eight phases ranging from 60s to 70% W, apart from 90s of active rest at 10% W. On the other hand, the sprint interval training (SIT) consisted of eight stages lasting 30s of effort up to 105% W, apart from active rest at 120s to 10% W.

In the research of Harnish et al. (2016) the training program included the use of a manual ergometer. The experimental program was realized in the period of 12 weeks three times a week, but only with one participant. The training program was a combination of HIT three times for 5 min at a level of ~ 70% of maximum power ($W_{max}$) and 5 min rest periods (HIT5); 4 times for 2.5 min at a level of ~ 85% $W_{max}$ and 5 min rest periods (HIT2.5); 10 times for 1 min at a level of 110% $W_{max}$ and 2 min rest periods (HIT1). Zone HRmax were set to values <75% HRmax (Z1), 75-89% (Z2), and 90% (Z3), to monitor the effectiveness of the training program.

Brazg et al. (2017) examined the intensity of locomotor training (LT) on walking performance in individuals with SCI. The participants realized a program consisting of 20 LI training sessions and HIT locomotor training for 1h with a frequency of three to five times a week.

Skucaš (2018) in his research examined the effects of strength and endurance programs on mental and physical health in people with SCI. The training program lasted for eight weeks, which included a strength training program and a durability training program. Also, the level of mental health taken into account in this research.

This study had a control and experimental group. The control group did not have an experimental program, while the experimental group realized the program through various activities, four times a week, 2h after gym training (twice a week during gym training), as well as endurance training (twice a week). The endurance training included moderate intensity trainings with a HRmax value of 60% with a maximum pulse of 167 $bmp \cdot min^1$ and an average pulse of 146 $bmp \cdot min^1$. Wheelchair rides were realized four times of 30 min, with recovery breaks every 5 min.

Based on the analysis of the studies, it can be concluded that the studies are heterogeneous, i.e., they differ in terms of the methodology of designing the experimental program, the duration of the program, the frequency of the program, and the variation of the intensity of the program. Regarding the design of the research, only one study had a control and experimental group (Skucaš, 2018), while the other studies did not have a control and experimental group. The limitation of this paper is reflected in a small number of scientific research studies that have satisfied the inclusion criteria.

A modest number of studies that meet the inclusion criteria can be explained by the fact that the organization of research involving people with disabilities can be very complex (Paravlić, Aleksandrović, Živković, Radovanović, Madić, Đorđević & Koničanin 2016). Also, the second limitation is reflected in the range of subjects for each study, not all the studies examined the difference in terms of the intensity of the exercise program, which may also be the methodological limitation of this study. On the other hand, only four studies compared the intensity of the exercise program in order to determine which intensity is suitable for improving the $VO_2$max value (Bougent et al., 2003; DeGoot et al., 2003; Astorino & Thum, 2016; Brazg al., 2017). In addition to limiting factors, there is an improvement in $VO_2$max in all studies (Bougenot et al., 2003; DeGroot et al., 2003; Widman et al., 2006; Lindberg et al., 2012; Astorino & Thum, 2016; Harnish et al., 2016; Brazg et al., 2017; Skučas, 2018).

Bougenot et al. (2003) found significant changes in the maximum tolerated power (MTP + 19.6%), $VO_2$max (+ 16%) in the production of carbon dioxide $VCO_2$ (+16.4%) and in the value of the oxygen pulse ($O_{2p}$ + 18%). At the ventilation threshold, there was a statistically significant improvement in the output power (PO + 63%), the ventilation threshold ($VO_{2VT}$ + 34.1%), ventilation (VEN + 37.1%), and in the value of oxygen pulse ($O_{2PVT}$ + 19.9%). Heart rate (HR) and ventilation (VEN) values were lower (-11 and -14.6%) after training at the same level of work. Between the first and last training, total physical work (TPW) was improved by 24.7%, where the HR value remained unchanged.

DeGroot et al. (2003) found that an eight week training program led to a significant increase in the $VO_2$max value and the maximum output power ($PO_{max}$) values for the whole group (p=0.05). Improvements in the $VO_2$max value were higher in the HIT group, i.e., the level after the training was 150% for the HIT group, and 117% for the LI group. The trend of increase in $PO_{max}$ was recorded in the HIT group (159%) compared to the LI group (124%).

In the research of Widman et al. (2006), participants increased the $VO_2$max value for at least 50% of their $VO_2$max reserve on the GameCycle ergometer before the start of the 16 week training program at home. Seven out of eight participants reached HRmax for at least 50% of their HRmax reserves. One participants did not reach 50% of $VO_2$max reserves or 50% HRmax reserves. After completing the training program at home, six out of eight participants increased their working ability during a manual ergometer test (from 65.5±9.7 to 77.7±7.1 W) ($P<0.015$).

The research of Lindberg et al. (2012), found statistically significant improvements in a person with SCI in terms of $VO_2$max values (22.7%), ventilation (20.7%) and blood lactate levels (22.0%) during maximum intensity exercise. The mean value of power and force was improved by 15.4% and 23.7% respectively. At a sub-maximal level, significant lower values were detected in ventilation (-12.8%) and blood lactate levels (-25%).

Astorino & Thum (2016) also significantly improved the $VO_2$max variable and at HRmax at the statistical level ($p<0.05$). The values of $VO_2$max and HRmax were higher

($p<0.05$) in HIT (90% $VO_2$max and 99% HRmax), at the sprint interval (SI) (80% $VO_2$max and 96% HRmax) compared to LI training.

Harnish et al. (2016) found that after completing 36 training courses lasting 12 weeks combined with 8 HIT5, 10 HIT2.5 and 5HIT 1, $W_{max}$ and $VO_2$max improved by 45% and 52% respectively, for 6 weeks, without further improvement up to 12 weeks.

On the other hand, Brazg et al. (2017)explored the effects of locomotor training on the kinematic parameters of the locomotor apparatus itself in a person with SCI in more detail, comparing the difference and impact of LI and HIT training, but also examined the physiological variables of the participants. The authors found that HIT training led to significant changes in selected locomotor and metabolic variables when compared to LI training.

Skucaš (2018), mainly in his research, examined the connection of exercise with mental health and strength, but he also examined functional abilities. He found that there were statistical improvements in the mental and physical health of the experimental group, compared to the participants of the control group. Isometric force and a 12 min wheelchair drive positively affected the strength and endurance of SCI.

## CONCLUSION

Based on the analysis of the studies, they confirmed that there was an improvement in $VO_2$max in people with SCI. On the other hand, only four studies examined the differences in terms of exercise intensity in order to find out which intensity is suitable for improving the $VO_2$max value. Studies have found that the $VO_2$max value can be enhanced by physically exercised intensified intensity (HIT) in relation to physical exercise of moderate intensity (LI). Considering the high level of heterogeneity of the scientific papers, the sample of participants, measuring instruments, experimental research, the conclusions should be taken with caution. Further research on the impact of physical exercise intensities on the improvement of $VO_2$max in people with SCI should be continued, with a larger sample of participants, with a control and experimental group, and that the studies should be longitudinal.

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# DA LI FIZIČKO VEŽBANJE MOŽE DA DOPRINESE POBOLJŠANJU $VO_2$max KOD OSOBA SA POVREDOM KIČMENE MOŽDINE? SISTEMATSKO PREGLEDNO ISTRAŽIVANJE

*Maksimalna potrošnja kiseonika ($VO_2$max) se smatra jednim od najrelevantnijih pokazatelja stepena stanja funkcionalnih sposobnosti kardiorespiratornog sistema kod pojedinca i sportista. Ona je pokazatelj funkcionalnog stanja i poznavanje vrednosti $VO_2$max je od velikog značaja za unapređenje funkcionalne forme kod sportista i kod rekreativaca, kao i u pravilnom planiranju, programiranju i doziranju aktivnosti. Cilj ovog istraživanja je bio pregledom literature utvrditi da li fizičko vežbanje može unaprediti $VO_2$max kod osoba sa povredom kičmene moždine. Za prikupljanje radova koristile su se sledeće elektronske baze podataka: KoBSON, Google Scholar, MEDLINE, PEDro, DOAJ i Open J Gate. Ključne reči koje su bile upotrebljene radi pretraživanja radova su: physical exercise, $VO_2$max, spinal cord injury, adaptation, training, effects, patients, intensity, aerobic, anaerobic, heart rate. Na osnovu inklizivnih i ekskluzivnih kriterijuma odabrano je 8 radova koje je zadovoljilo postavljene kriterijume. Analizirajući radove, samo su 4 rada ispitivala razlike u pogledu intenziteta vežbanja sa ciljem saznanja koji intenzitet je pogodan za unapređenje vrednosti $VO_2$max. Istraživanja su utvrdila da se vrednost $VO_2$max može unaprediti fizičkim vežbanjem povećanog intenziteta (HIIT) u odnosu na fizičko vežbanje umerenog intenziteta (LI). Ako se uzme u obzir visok stepen heterogenosti radova, uzorka ispitanika, mernih instrumenata, eksperimentalnog istraživanja, zaključke je potrebno donositi sa oprezom. Potrebno je nastaviti sa daljim istraživanjima uticaja intenziteta fizičkog vežbanja na poboljšanju vrednosti $VO_2$max kod osoba sa SCI, sa većim uzorkom ispitanika, sa kontrolnom i eksperimentalnom grupom i da studije budu longitudinalne.*

Ključne reči*: povreda kičmene moždine, fizičko vežbanje, terapija, fizički fitnes, zdravlje*