

FUNCTIONAL IMPAIRMENT IN MULTIPLE SCLEROSIS

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Abstract

The aim of this study was to analyse the physical fitness, functional parameters, fatigue, and independence in a group of patients with multiple sclerosis (MS), and to compare the results measured with applicable standards.

We examined 35 MS patients with a clinically active form of MS (age 49.1 ± 10.0 years, 28 women, 7 men, mean duration of MS 15.4 ± 12.5 years, EDSS 3.0 ± 1.2) who participated in spiroergometric examination. All the patients underwent a symptom-limited spiroergometry on a bicycle (load 20 W increasing every 2 min) in order to evaluate the following parameters of functional capacity: maximal oxygen consumption ($\dot{V}O_{2\text{peak}}$ -ml O_2 , $\dot{V}O_{2\text{peak}}$ ·kg⁻¹, -ml O_2 · kg⁻¹), maximal work load (W_{peak} -watts, W_{peak} kg⁻¹ watts.kg⁻¹). We measured the following haemodynamic parameters: heart rate (HR) and blood pressure (SBP and DBP). The data registered were compared with Czech standards (IBP standards – International Biological Program, Seliger et al., 1977). The patients were also tested for fatigue (MFIS questionnaire) and functional independence measure (FIM).

The results showed a significant reduction of functional capacity, namely in the values of spiroergometry parameters ($P < 0.05$, Wilcoxon paired) $\dot{V}O_{2\text{peak}}$ (1432.9 ± 474.4 ml O_2), $\dot{V}O_{2\text{peak}}$ ·kg⁻¹ (20.6 ± 5.9 ml O_2 ·kg⁻¹), W_{peak} (89.0 ± 34.1 watts), and W_{peak} ·kg⁻¹ (1.29 ± 0.4 watts.kg⁻¹) at the exercise peak. Correlations between clinical testing (EDSS), fatigue (MFIS), and spiroergometric data (Spearman coefficient) were obtained.

The examined patients with MS have a low exercise tolerance and a rather low capacity of the transport system. Spiroergometric parameters depend on the degree of clinical disability and subjectively evaluated fatigue.

Key words

Multiple sclerosis, Functional disability

INTRODUCTION

Multiple sclerosis (MS) is a chronic system autoimmune disease bringing about a functional neurological deficit on the basis of dissemination of demyelination focuses in the CNS area (1). At the beginning of the disease there also appears axon involvement, which is probably the cause of persisting neurological deficit. The

maximum axon loss occurs in the first years of the disease (a period with minimal disability and clinical finding) and, as a result of depletion of the functional reserves of CNS, a substantial deceleration in conducting nerve impulses develops. Another axon loss already brings an irreversible disability (2). Demyelination and axon involvement are localised particularly in the periventricular area, in the brain stem, cerebellum, lateral and posterior cords of the spinal cord. Predominant manifestations include central pyramidal symptoms, cerebral, stem and sensitive signs, disorders of autonomous regulation, continence, etc. (3). Multiple sclerosis also attacks basic physiological response to load by demyelination processes (4, 5). Functional changes in skeletal musculature, particularly reduction of the number of fibres of type I, reduction of oxidative abilities, and prevailing anaerobic activity of skeletal extrafusal fibres (6) are ranked among other pathophysiological processes. Increasing health troubles lead to secondary signs of physical deconditioning with a gradual reduction of muscular mass, appearance of functional troubles, and further reduction of cardiorespiratory fitness (7). However, it is probably caused by deconditioning in consequence of the lack of physical activities. Restriction of physical activities in MS patients was confirmed (8). It could be primarily caused by muscle weakness and fatigue (9). It is suggested that aerobic exercises and strengthening may help to prevent secondary changes partially caused by deconditioning (10). Controlled exercising activity represents a significant element influencing physical deconditioning and the course of MS disease (4, 11-14). Assessment of the functional condition of cardiorespiratory and metabolic activity and of the determination of functional reserves could help to set up an optimal individual rehabilitation workload with adequate intensity (11-15).

PURPOSE

The study was aimed at analysing physical fitness, metabolic and haemodynamic functions in a set of patients with MS, and at a comparison of the results measured with actual standards, and investigation of fatigue and independence.

METHODS

The set examined consisted of patients from a neurological outpatient clinic for MS of First Department of Neurology, St. Anne's Faculty Hospital and patients in the city of Brno. The patients were tested in a clinically stabilised disease condition. They confirmed by signature of "Informed consent of the patient" their participation in the study. The study was approved by the appropriate ethical commission of St. Anne's Faculty Hospital in Brno. Evaluation of clinical disability, independence and fatigue was carried out before the exercise examination.

The exclusion criteria of contraindications for undergoing spiroergometry and the ability of the patient to undergo the examination on a bicycle ergometer were

the criteria for inclusion. Patients with internal, metabolic and other diseases which could influence the validity of the exercise test results were excluded.

We used the following tests for clinical functional impairment:

EDSS (Kurtzke's Expanded Disability Status Scale) (16) is a standard scale for evaluation of clinical disability in patients with MS. It is a neurological examination with evaluation by 0.5 point, at an interval from 0 (no functional disorder or impairment) to 10 (death due to MS), MS impact on 8 basic functional systems.

FIM (Functional Independence Measure) (17) is a scale for evaluation of independence in basic daily activities. Evaluation applies to locomotive skills, mental functions, and general degree of independence. Possible range is 18–126 points.

MFIS (Modified Fatigue Impact Scale) (18) is a questionnaire including subjective assessment of fatigue impact on physical condition (MFISp), cognitive (MFISc), and psychosocial functions (MFISps). It contains 21 questions with an evaluation of 0 – 4 points (0 – on fatigue impact on the function; 4 – almost permanent fatigue impact). The possible range is 0 to 84 points.

Examinations of physical fitness and oxygen transport system:

Symptom-limited spiroergometry was carried out in standard conditions (15) on a bicycle ergometer (system for the analysis of respiratory gases, MedGraphics, USA). The load was measured out in 2-min intervals by 20 W. The examination determined the following functional parameters: peak work capacity (W_{peak}), peak work capacity per kg of body mass ($W_{peak} \cdot kg^{-1}$), peak oxygen consumption (VO_{2peak}), peak oxygen consumption per kg of body mass ($VO_{2peak} \cdot kg^{-1}$), pulse oxygen ($VO_2 \cdot SF^{-1}$), minute ventilation (VE), and relative ventilation ($VE \cdot kg^{-1}$). Then the resting and highest achieved values of systolic pressure (SBPrest and SBPpeak) and diastolic pressure (DBPrest and DBPpeak), and the resting and highest achieved values of heart rate (HRrest and HRpeak) were recorded. The resulting values were mathematically processed and compared with actual IBP standards for Czechoslovak healthy population (International Biological Program, 1977) (19). Statistical data analysis (program STATISTICA for Windows – version 7.7) was carried out by means of the Wilcoxon test for non-paired values and correlation analysis (Spearman, r , $P < 0.05$) of individual parameters.

RESULTS

Thirty-five patients with diagnosed MS disease were examined – 28 women (80 %) and 7 men (20 %) of mean age 49.1 ± 10 years. The degree of disability according to EDSS was 3.0 ± 1.2 (medium degree of disability). In 17 patients we found a relapse-remittent (RR) form of the disease, in 16 patients a secondarily progressive (SP), and in 2 patients a primarily progressive (PP) form of the disease. In the MFIS questionnaire the patients assessed their fatigue on average as moderate to medium, with an approximately identical influence of physical and cognitive deconditioning. Independence, tested by the FIM scale, achieved the upper limit of the scale range, i.e.,

minimal limitation of independence in doing common daily activities. The general characteristics of the set and evaluation of the disease activity are given in *Table 1*.

Table 1

Basic anthropometric data and data defining MS disease in the set examined (the values are expressed as mean \pm SD)

	Achieved value	Min. and max. values
Clinical disability (EDSS)	3.0 \pm 1.2	0–10
Fatigue (MFIS)	32.3 \pm 17.9	0–84
MFISp – physical	16.8 \pm 8.9	0–36
MFISc – cognitive	12.7 \pm 8.4	0–40
MFISps – psychosocial	2.7 \pm 2.3	0–8
Independence (FIM)	116.3 \pm 10.9	18–126
Body mass index (BMI)	24.7 \pm 4.6	
Length of MS disease (years)	15.4 \pm 12.5	
Age (years)	49.1 \pm 10.0	

Parameters of physical fitness and metabolic functions

Statistical evaluation of the mean values found in examinations indicated a significant decrease of most parameters of functional fitness in patients from the monitored set in comparison with actual IBP standards. The given finding demonstrates a significantly lower functional fitness in MS patients. A detailed survey of the results and statistical evaluation are given in *Table 2*.

Table 2

Measured values of spiroergometric parameters in comparison with the Czech IBP standard (the values are expressed as mean \pm SD)

Spiroergometric parameters	Value measured	Value according to IBP standard	Statistical significance
W_{peak} (W)	89.0 \pm 34.1	176.3 \pm 28.4	***
$W_{peak} \cdot kg^{-1}$ (W $\cdot kg^{-1}$)	1.29 \pm 0.4	2.5 \pm 0.3	***
HRpeak	140,8 \pm 23,8	177.7 \pm 7.5	***
VO_{2peak} (ml O_2)	1432.9 \pm 474.4	2021.1 \pm 320.4	***
$VO_{2peak} \cdot kg^{-1}$ (ml O_2)	20.6 \pm 5.9	28.5 \pm 3.2	***
$VO_{2peak} \cdot SF^{-1}$ (ml.tep $^{-1}$)	9.9 \pm 3.0	11.4 \pm 0.02	*
VE (L.min $^{-1}$)	44,9 \pm 18,6	78.3 \pm 12.5	***
VE.kg $^{-1}$ (L.min $^{-1}$.kg $^{-1}$)	0.7 \pm 0.3	1.11 \pm 0.14	***
RER	1.0 \pm 0.1	1.1 \pm 1.8	**

* P < 0.05 ** P < 0.001 *** P < 0.0001

Haemodynamic parameters

The average resting values of systolic blood pressure at rest (SBP_{rest}) were 125.4 ± 15.1 mmHg, of diastolic blood pressure at rest (DBP_{rest}) 82.3 ± 9.1 mmHg, and of heart rate at rest (HR_{rest}) 72.8 ± 12.6 pulses.min⁻¹. The following factors participated in terminating the exercise test: sudden appearance of total fatigue, probably due to MS (36 %), fatigue of musculature of lower extremities (48 %), and achieving of hypertonic reaction of BP (16 %). The statistical evaluation showed, however, significantly lower values of the peak heart rate at the lower achieved maximum performance and significantly higher values of DBP_{max} (97.2 ± 21.4 mmHg) at the peak of the load in comparison with actual Czech IBP standards. As to SBP_{max} values, no statistical significance was proved. A rather low value of HR_{max} and increased values of DBP_{max} could indicate a decreased level of physical performance and pathological (hypertonic) reaction of DBP as a response of the organism to physical loading by a dynamic form. Decrease of SBP in the restitution phase showed normal values on average. A survey of the results is listed in *Table 3*.

Table 3

Measured values of haemodynamic parameters in comparison with Czech IBP standards (the values are expressed as mean \pm SD)

Haemodynamic parameters	Value measured	Value according to IBP standard	P level (Wilcoxon)
SBP_{max} (mmHg)	186.0 ± 27.7	177.9 ± 8.0	NS
DBP_{max} (mmHg)	97.2 ± 21.4	77.5 ± 8.6	***
HR_{max} (pulse.min ⁻¹)	140.8 ± 23.8	177.7 ± 7.5	***

* $P < 0.05$ ** $P < 0.001$ *** $P < 0.0001$

After statistical evaluation, correlation analyses between neurological impairment (EDSS), MFISp, FIM, and parameters of functional fitness and metabolic functions were carried out. The general results of the analysis are given in *Table 4*. The most important relation was found between spiroergometric parameters and EDSS, and then in the MFISp subscale. The assumption of a close relation between the FIM and MFIS scales has been proved ($r = -0.56$, $P < 0.001$). In our set we have not found any relation between FIM and EDSS ($r = -0.05$, NS), between EDSS and MFIS ($r = 0.28$, NS); we have only found a small dependence between EDSS and the length of the disease ($r = 0.35$, $P < 0.01$). All correlation analyses were carried out, however, on a statistically small sample of patients.

Table 4

Correlation between parameters of the spiroergometry and selected clinical parameters (the values are given as Spearman coefficient r)

	Length of disease	EDSS	MFIS	MFISp	FIM
W_{peak} (W)	-0.30	*** -0.67	* -0.41	** -0.50	0.08
$W_{peak} \cdot kg^{-1}$ ($W \cdot kg^{-1}$)	-0.27	*** -0.58	* -0.42	** -0.49	0.10
HR _{peak}	* -0.37	** -0.48	* -0.39	* -0.38	0.08
VO_{2peak} (ml O_2)	-0.24	** -0.64	** -0.43	** -0.56	0.12
$VO_{2peak} \cdot kg^{-1}$ (ml O_2)	-0.15	** -0.47	* -0.38	** -0.48	0.13
$VO_{2peak} \cdot SF^{-1}$ (ml.tep ⁻¹)	-0.10	** -0.48	-0.14	-0.31	-0.11
VE (L.min ⁻¹)	-0.32	** -0.48	* -0.41	** -0.51	0.12
$VE \cdot kg^{-1}$ (L.min ⁻¹ .kg ⁻¹)	-0.21	* -0.36	* -0.42	** -0.49	0.20

* $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

DISCUSSION

A significant decrease of the parameters of cardiorespiratory fitness in comparison with normal population is documented in a number of studies (4, 11, 12, 13, 20, 21). Many of them are resumed in the study of *Motl et al.* (22). Concerning the Czech studies published in the world, especially the study of *Řasová et al.* (23) presents comprehensive results of spiroergometric measurements made on a sample of 112 patients with MS; in the majority of the cases we are in accordance with the results and conclusions of this study. The results of our measurement represent the choice of the population of MS patients with quite a low degree of subjectively perceived fatigue (MFIS 32.3 ± 17.9), a high degree of independence (FIM 116.3 ± 10.9 , 74 % of the patients did not use any aids of locomotion), and a relatively low degree of EDSS (3.0 ± 1.2) (24). The results of our study showed a statistically very significant limitation of the functional capacity of the cardiorespiratory system and physical fitness in comparison with actual standards applicable to Czechoslovak population (19). The patients in the set with MS manifested a rather low tolerance of dynamic load and quite a low ability of achieving maximal values of physical performance (23, 21). This fact also corroborates a preliminary termination of the test. It can be explained by the block of conduction of nerve impulses increasing with the increasing load (2, 21). Under the load two patients suffered heart rhythm disorders that were not too grave and were not the reason for interrupting the test. The pressure reaction of the examined set to the dynamic load showed a hypertonic reaction DBP_{max} at the

load peak. This reaction can be explained by a higher vascular resistance and a lower vascular elasticity in consequence of the long-time physical inactivity, and by a higher mean age of the set (15). Our results also imply a correlation between the degree of neurological impairment (EDSS), MFISp, and spiroergometric parameters. The results achieved are limited by the size of the set. New rehabilitation methods demonstrate decreasing fatigue (MFIS) and reduction of clinical impairment (EDSS) on the basis of increasing cardiorespiratory fitness (4, 11, 12). According to Zálišová *et al.* (25) physical condition and fatigue can be influenced by suitably chosen rehabilitation and fatigue should not be taken as the load limit. The results of the exercise test therefore represent, last but not least, a significant contribution to the prediction of the load measured out optimally, mainly objectively and relevantly, in rehabilitation programs for MS patients with quite a low degree of clinical impairment.

CONCLUSION

The results of spiroergometry showed that in the examined set of MS patients there is a very low tolerance of physical load and a rather low capacity of the transport system. The study demonstrates a correlation between the results of the spiroergometry and clinical functional impairment according to EDSS and fatigue according to the MFIS questionnaire.

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