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Physical Activity in Prevention of Risk and Disability in some Neurological Diseases

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Abstract

The question of the role of physical activity in preventing disability in neurological diseases
is the issue which is not in doubt. There is well known that physical activity in Parkinson`s disease and in Multiple Sclerosis patients is less than is the case in the general population.
Numerous scientific studies have confirmed the low physical activity of people with PD and MS. Improving physical activity delays the progress of physical disability and has the effect on increasing the quality of life in those two diseases.
In this paper an descriptive review of the literature devoted to the effect of physical activity on risk of PD and its impact on disability progression in PD and MS has been presented. The different recommendations for physical activity and different methods of assessment have been described.

Keywords: disability; Multiple Sclerosis; Parkinson`s disease; physical activity; prevention

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PHYSICAL ACTIVITY AND RISK OF PARKINSON`S DISEASE

Ashe et al. (2009), who conducted in Canada research into the activeness of individuals over the age of 65 emphasise that there exists an increased risk of inactivity connected with aging - one increased for those suffering from a chronic disease. They recommend the achieving of a weekly level of physical activity of the order of ≥ 1000 kcal/week. Colcombe et al. S.J., 2006, stated that aerobic exercise training increases brain volume in aging humans.

Parkinson`s disease (PD), which affects about 2% of the population over 65 years and more than 4% of those over 85 years, is one of the most frequent causes of physical disability from among the diseases of the nervous system. A few scientific studies have confirmed the low physical activity (PA) of people with Parkinson`s disease. In spite of modern treatment, one is not able to control the progress of physical disability within Parkinson`s disease. Recent reports showed that PA plays also an important role in morbidity of PD. In the scientific literature, one can find a lot of research which shows that exercise and physical activity lead to a reduction in mortality, an improvement in strength, the sense of balance and posture, mobility and independence in performing Activities of Daily Living (ADL) amongst patients with PD. Exercise and PA play an important role in the prevention of falls, which can be dangerous for patients. This publication lays out directions for new behavioural interventions aimed at increasing PA in PD. From many pieces of research one can state that exercises and physical activity reduce mortality, improve strength, well-being, mobility and independence in the carrying out of daily activities for individuals with PD.

There are several studies on the subject of the importance of PA in the initial prevention of PD. Only six prospective studies examined physical activity and risk of Parkinson's disease (Chen et al., 2005; Logroscino et al., 2006; Thacker et al., 2008; Xu et al., 2010; Saaksjarvi et al., 2014, Yang et al., 2014). Chen et al. claimed in 2005 that greater physical activity (PA) is connected with a reduced risk of developing Parkinson's disease in men. During the course of almost 20 years of the prospective observation of 48,574 men and 77,254 women, there were identified 252 (men) and 135 (women) cases of PD. Intensive exercises at a young age was inversely proportional to the risk of PD in men. In comparison to men who regularly exercised for a mere 2 months a year, men exercising intensely for 10 months had a 60% lower risk of developing PD (RR 0.4; p=0.005). In women PA was not connected with a risk of PD, while intensive exercise in early adulthood was inversely proportional to the risk of PD (2005).

In 2006 Logroscino et al. described the results of research into the relations between PA and PD in 10,714 men of an average age of 67.6, who had participated in the Harvard Alumni Health Study, who were free of self-reported PD in 1988. They were asked about the daily number of blocks of walking (1 block = 235 kJ/week = 56 kcal), walking up stairs (118 kJ/week) and their participation in sporting and recreational activities during the previous week. The energy expenditure was then estimated and men were divided into four groups: <1000, 1000/99, 2000-2999 or ⩾ 3000 kcal / week. The cases of PD occurring after 1988
(n = 101) were verified through a supplementary health questionnaire in 1993 and death certificates collected up until 1997. As a result of a multi-factor analysis it was claimed that the relative risk (RR) for Parkinson's Disease was connected with the levels of physical activity <1000, 1000/99, 2000-2999 and 3000 kcal / week were respectively: 1 (referential), 1.15 (95% of the confidential interval (95% CI) 0.71 to 1.88), 0.92 (0.50 to 1.71) and 0.63 (0.36 to 1.12); *p* for the trend = 0.12. If walking was evaluated separately, then a somewhat lower but non-significant risk of PD was noted. In the multi-factor analysis for walking <5, 5-10, 10-20 and > 20 km / week the relative risk (RR) (95% CI) was respectively 0.67 (0.37 to 1.23), 0.81 (0.50 to 1.31) and 0.72 (0.39 to 1.34); *p* for the trend = 0.26. The authors' conclusions: this data did not unequivocally confirm the hypothesis that PA reduces the risk of PD. However, as the number of patients with PD in this test was not large, statistical power may have been limited and therefore it will be necessary to conduct further large-scale tests to provide additional data.

The same group of researchers described in 2007 the results of tests conducted on the same material with the aim of checking the hypothesis that the Body Mass Index is connected with PD risk. The average Body Mass Index (BMI) of the testees was 24.7 (SD 3,0) kg/m^2; 42% amongst them were overweight. Amongst 106 new cases of PD, the Body Mass Index at the beginning of tests was not connected with a risk of the disease. The patients who lost at least 0.5 of a BMI unit over a decade between the beginning of their university degree and the year 1988 had a greater risk of PD when compared to men of a stable BMI (multi-factor relative risk = 2.60, 95% confidential interval: 1.10, 6.10).

Yang et al. (2014) examined the impact of physical activity on Parkinson's disease risk prospectively, in the frame of the Swedish National March Cohort. They followed 43 368 individuals who provided extensive information on physical activity at baseline. During an average of 12.6 years of follow-up, 286 incident Parkinson's disease cases were identified. In males, there was an inverse association with Parkinson's disease for total physical activity (hazard ratio 0.55, 95% confidence interval 0.35-0.87 for medium versus low level), for sum of household, commuting and leisure time exercise (hazard ratio 0.53, 95% confidence interval 0.33-0.85 for high versus low level), and for household and commuting physical activity specifically (hazard ratio 0.50, 95% confidence

interval 0.31-0.81 for >6 versus <2 h per week). No association was observed for leisure time exercise or occupational physical activity with Parkinson's disease, among either males or females. Meta-analysis of this study and five previous prospective studies showed a pooled hazard ratio of 0.66 (95% confidence interval 0.57-0.78) for highest versus lowest physical activity level. Those results indicate that a medium level of physical activity lowers Parkinson's disease risk.

Sasco et al. described in 1992 the results of clinical-control research conducted for the period 1916-1978 on a large number of men, 50,002, by the universities of Harvard and Pennsylvania. The connection between PA and the risk of PD was evaluated in 137 men, who during this period had fallen ill with PD and 548 from the control group. The data on PA in adults prior to the manifestation of the disease was available in 94/137 of the patients. Membership of a university sports association or the carrying out of regular physical exercises was connected with a lowered risk of developing PD, although this relationship did not turn out to be statistically significant. The practicing of areas of sport connected with a high level of physical exertion was statistically significantly linked to a lower risk of illness and was non-significant statistically in cases of moderate physical exercise.

PHYSICAL ACTIVITY AND DISABILITY IN PARKINSON`S DISEASE

In the evaluation of PD prognosis, Post et al. (2007) and Suchoversky et al. (2006) pointed to the significance of age, disturbances to the cognitive functions and depression, while in the newest report Velseboer et al. considered being male as a risk factor for the appearance of early disability (2013). There has been observed a natural inclination on the part of PD patients to engage in less physical activity than in the general population. Van Nimwegen et al. published in 2011 the results of research into the daily PA of 699 individuals with PD and 1959 from a control group brought together within the framework of the ParkinsonNet programme. In patients with PD there was noted a reduction in PA by 29% when compared to the control group (95% CI 10-44%). It was shown that a greater intensification in the disease, disturbance to gait and reduced independence in the carrying out of daily activities (ADL) correlates to reduced physical activity. This maintaining of reduced physical activity may be detrimental for patients and may accelerate the development of the disease.

Crizzle and Newhouse have conducted a critical analysis of studies on rehabilitation and physical activity in PD as noted in the most well-known medical databases. Seven pieces of research that met the selected criteria were chosen, in which part from 6 to 438 participants took part; the time period for intervention was from 4 weeks to 4.1 years. On the basis of this review they have come to the conclusion that exercise and physical activity reduce mortality, improve strength, the sense of balance, mobility and independence in the carrying out of daily activities for individuals with PD (2006).

Fertl et al. in 1993 described the results of research into PA in 32 patients with PD aged 65.6 ±8.1 years. This data was compared with that of 31 healthy individuals aged 61.7 ±5.8 years). Up until the moment of the first symptoms of the disease (mean = 58.5 years) PA within the patients did not differ from that of the control group. During the course of the disease there occurred a startling reduction in the amount of PA. In both groups a preference was shown for swimming, rambling and gymnastics. The learning of new sporting disciplines seems to be impossible for those suffering from PD.

Speelman et al. described in 2011 the results of a systematic review of reports on exercise and PA in PD. They draw attention to the support given to avoiding a sedentary life style as well as support for promoting PA (including muscle strengthening exercises, aerobics and stamina building exercises) both for those suffering from and those threatened with the development of PD. However, the present state of knowledge does not allow us to point to concrete types of PA that are to be especially favoured by PD patients. In propagating an active life style in patients with PD one must not forget about matters of safety. Exercises must be adapted individually to the patient's possibilities and abilities. An exercise programme must equally take into consideration various barriers which could make an active style of life difficult for PD patients such as apathy, fatigue, depression and disturbance in cognitive functions. The main aim of such an approach is the causing of lasting changes in behaviour patterns, with the hope that this will slow down the progression of the disease. If a given exercise is shown to have a modifying effect on the disease then the ultimate goal will be the devising of an action strategy which will enable the regeneration or prevention of the appearance of the initial symptoms of the disease in a symptomless population burdened with an increased risk of the onset of PD (2011).

Few researches on animals has brought information showing the possibilities of a neuroprotective effect in experimentally induced Parkinson's, but these results still await confirmation in tests on humans. Exercise on a treadmill resulted in a reduction in the depletion of dopamine in the striatum of rats with an experimental model of PD, when compared to animals who had not trained, evaluated in vivo by means of releasing a rotation of apomorphines and a postmortem analysis of dopamine. Nonetheless training exercises on the treadmill did not result in fundamentally any difference in the behavioural deficits for the majority of the tests when compared to animals that had not exercised. The maintaining of physical activeness in humans is today treated as a factor allowing one to maintain or improve cognitive

functions, as equally improving the functions of the frontal cortex in the old.

PHYSICAL ACTIVITY AND DISABILITY IN MULTIPLE SCLEROSIS

Multiple sclerosis (MS) is the third most common cause of disability among neurological diseases, after stroke and Parkinson's disease (PD). The true is that patients with MS have less physical activity (PA) than the general population. Cross-sectional studies conducted among 14,500 residents of the county of Hordaland in Norway (1997), including 87 patients with MS, have shown that patients with MS had a high rate of smoking, low average Body Mass Index (BMI) and lower levels of PA compared to the rest of the study population.

The leading role in the studying of physical activity in the MS pays team of the Faculty of Kinesiology and Public Health at the University of Illinois (Department of Kinesiology and Community Health University of Illinois at Urbana-Champaign) under the direction of Professor Robert Motl. In one of the numerous reports they pointed to the link between the environment and the characteristics of PA in adults with MS. It turned out that the presence of shops and super-markets within walking distance, the presence of public transport within walking distance and the availability of free or low-cost forms of recreation were correlated with indications pedometer measures the AF. This indicates the importance of easy access to recreation.

Dlugonski et al., from the team above described in 2012 the results of randomized research into the influence of Internet behavioral intervention based on a video-coaching on increasing and maintaining PA in individuals with MS. Each patient possessed his/her own personal coach, who, during the course of three months, conducted a total of seven online sessions by encouraging aimed at increased PA. In the evaluation of results the Godin Leisure-Time Exercise Questionnaire (GLTEQ), 29-item Multiple Sclerosis Impact Scale (MSWS-12), Patient Determined Disease Steps (PDDs) and the 29-item Multiple Sclerosis Impact Scale (MSIS -29) has been used. After 12 weeks in the group with intervention (n = 22) it claimed the marked increase in PA when compared to the control group (n = 23).

In the first study, signed by Dlugonski et al., Participants (n = 21) wore ActiGraph 7164 accelerometer for 7 days, and completed a questionnaire and a questionnaire iPAQ Godin (GLTEQ) before and after the 12-week intervention using the Internet. Questionnaire Godin (Godin Leisure-Time Exercise Questionnaire) was described in 1985. GLTEQ used for self-AF. In the first part of the most commonly used questionnaire consists of three items. Estimated frequency of exercise significantly aggravating (eg. running, jogging, intensive swimming), moderate (eg. brisk walking, cycling, swimming without fatigue) and mild (eg. Yoga, walking) performed at least 15 minutes during leisure free time during the week. Each of these forms of AF (aggravating, moderate and mild) is assigned a metabolic equivalent (MET) - respectively, 9, 5 and 3. The total score GLTEQ can range from 0 to 119. Intervention using the Internet resulted in little increase in the registration AF accelerometer (d = 0.68) and the number of steps (d = 0.60). This was associated with a slight increase of AF assessed iPAQ questionnaire and questionnaire GLTEQ.

In another report from 2011, a team from the University of Illinois study described the oxygen cost of walking on a treadmill and on the sidewalk in 42 people with MS with mild motor dysfunction. Oxygen cost of walking was significantly higher in MS than in the control group and was significantly associated with walking speed. Physical Disability clearly correlated with the cost of aerobic walking. Proposal authors: it has been shown that oxygen is an indicator of the cost of walking disorder walking in patients with MS, with mild physical disability. In recent months, they released two interesting reports signed in 2012.

Sandroff et al. (2012), compared the AF between two equally-actual numerical groups of 77 patients with MS and controls, matched for age, height, weight and sex. It was found statistically significant differences between groups in the assessment of activity, in terms of the number of steps, time spent in moderate to intense exercise, the results on a scale GLTEQ and performance on a scale IPAQ. The average score of the five scales showed that individuals with MS generally were moderately less physically active than the control group. Conclusions: The main finding was a moderate reduction in physical activity among people with MS, but its scale was much smaller than previously announced in the published meta-analysis.

The degree of atrial fibrillation in patients with MS can be improved by providing them with behavioral interventions. Often used in psychotherapy, behavioral therapy is aimed at both the removal of negative behaviors, as well as generation and establishment of new ones. In the process of behavioral therapy distinguishes four phases: diagnostic, inducing motivation, the use of a specific therapeutic procedure and fixation of changes occurred during psychotherapy. For therapeutic techniques used in behavioral therapy include stimulus control, setting goals and monitoring their own behavior. Motl et al. described the relationship between changes in individual-level AF, self-efficiency and quality of life depends on the health - Health-Related Quality of Life (HRQOL) for a period of one year follow-up. The sample consisted of 269 patients with relapsing-remitting MS (RRMS). The subjects completed a questionnaire Godin (GLTEQ), MSSE questionnaire (Multiple Sclerosis Self-Efficacy Scale) and MSIS-29 questionnaire (Multiple Sclerosis Quality of Life-29) twice - before and after the observation year. Preliminary analysis showed that the

change in the individual level of AF was associated with a change in the individual quality of life both in the physical as mental. Subsequent analysis showed that the change in the individual's own assessment of the level of performance in patients with MS was associated with a change in the individual level of HRQOL in the physical realm, while the change in the individual's own assessment of the level of efficiency in the control group was associated with a change in the mental HRQOL. Individual level to assess their performance was the strongest predictor of changes in quality of life. Conclusions authors: AF and self-efficiency may be important targets for subsequent behavioral interventions to improve the quality of life of people with MS, although self-efficiency is apparently more important than the PA (2013).

Recently Anens et al. (2014) studied the levels of physical activity, self-efficacy for physical activity, fall-related self-efficacy, social support for physical activity, fatigue levels and the impact of MS on daily life, in addition to investigating gender differences. The sample for this cross-sectional cohort study consisted of 287 (84 men; 29.3%) adults with MS recruited from the Swedish Multiple Sclerosis Registry. A questionnaire was sent to the subjects consisting of the self-administrated measurements: Physical Activity Disability Survey - Revised, Exercise Self-Efficacy Scale, Falls-Efficacy Scale (Swedish version), Social Influences on Physical Activity, Fatigue Severity Scale and Multiple Sclerosis Impact Scale. Response rate was 58.2%. In results: men were less physically active, had lower self-efficacy for physical activity and lower fall-related self-efficacy than women. This was explained by men being more physically affected by the disease. Men also received less social support for physical activity from family members. The level of fatigue and psychological consequences of the disease were similar between the genders in the total sample, but subgroups of women with moderate MS and relapsing remitting MS experienced more fatigue than men. Authors conclusions: men are less physically active, probably a result of being more physically affected by the disease. Men being more physically affected explained most of the gender differences found in this study. However, the number of men in the subgroup analyses was small and more research is needed. A gender perspective should be considered in strategies for promoting physical activity in subjects with MS, e.g. men may need more support to be physically active.

Najafidoulatabad et al. (2014) explored the effect of yoga techniques on physical activities and sexual function among some Iranian women with MS. In this study, 60 Iranian women with multiple sclerosis (MS) were placed in two equally divided control and case groups through random selection to assess pre-and post-effects of yoga exercises on their physical activities and sexual satisfaction levels. Women in case group were offered a series of yoga training and exercises for 3 months, which consisted of 8 sessions per month for 60 to 90 minutes at each session. Yoga training program included the 3 principles of slow motions (Hatayoga), respiratory exercises (Pranayama) and centralization to control mind via meditation, expansion and stasis (Rajayoga). After 3 months both groups were surveyed using the initial questionnaire to evaluate and compare findings with the base-line data. In results:
researchers found significant statistical difference in physical activity and sexual satisfaction levels among the women in case group (P=0.001). Women in case group showed improvement in physical ability while women in control group manifested exacerbated symptoms. Authors conclusion: Yoga techniques may improve physical activities and sexual satisfaction function of women with MS (2014).

SUMMARY AND DISCUSSION

In the scientific literature, one can find a whole series of reports on the role of AF in primary and secondary prevention of diseases of the nervous system. It is also mentioned as an important element of a comprehensive rehabilitation, relating to stroke, PD and Alzheimer's disease. The important role of the PA is emphasized in the recommendations and systematic reviews of rehabilitation in MS. Recently, Jackson et al. Have proposed even practicing kickboxing in MS. Physical activity is important component of a comprehensive rehabilitation in MS.

The article presents a pictorial overview of the current state of knowledge on the PA in PD and MS. Most authors draws attention to the sedentary life of patients with PD and MS and their low PA compared to the general population. High PA is correlated with delayed motor disability and a higher quality of life. In final conclusion: maintaining of regular moderate physical exertion – such as walking, cycling, or practicing various forms of sport and recreation – brings noticeable benefits in preventing disability in PD and MS.

REFERENCES

1. Ahlskog JE. Does vigorous exercise have a neuroprotective effect in Parkinson disease? *Neurology*, 2011; 77(3):288-294
2. Anens E, Emtner M, Zetterberg L, Hellström K. Physical activity in subjects with multiple sclerosis with focus on gender differences: a survey. *BMC Neurol*, 2014; 14:47-56

3. Ashe MC, Miller WC, Eng JJ, Noreau L. Physical Activity and Chronic Conditions Research Team. Chronic Disease and Leisure-time Physical Activity. *Gerontology*, 2009; 55(1):64–72
4. Chen H, Zhang SM, Schwarzschild MA, Hernán MA, Ascherio A. Physical activity and the risk of Parkinson disease. *Neurology*, 2005; 64:66-69
5. Colcombe SJ, Erickson KI, Scalf PE, Kim JS, Prakash R, McAuley E, et al. Aerobic exercise training increases brain volume in aging humans. *J Gerontol A Biol Sci Med Sci*, 2006; 61(11):1166-1170
6. Comelia CL, Stebbins GT, Brown-Toms N, Goetz CG. Physical therapy and Parkinson's disease. A controlled clinical trial. *Neurology*, 1994; 44(3):376-378
7. Crizzle AM, Newhouse IJ. Is physical exercise beneficial for persons with Parkinson`s Disease? *Clin J Sport Med*, 2006; 16: 422-425
8. Cruise KE, Bucks RS, Loftus AM. et al. Exercise and Parkinson's: benefits for cognition and quality of life. *Acta Neurol Scand*, 2011; 123(1):13-19
9. Deane KH, Jones D, Playford ED. Physiotherapy for patients with Parkinson`s Disease: a comparison of techniques. *Cochrane Database Syst Rev*, 2001; 3:CD002817
10. de Goede CJ, Keus SH, Kwakkel G, Wagenaar RC. The effects of physical therapy in Parkinson's disease: a research synthesis. *Arch Phys Med Rehabil*, 2001; 4:509-515
11. Dlugonski D, Motl RW, McAuley E. Increasing physical activity in multiple sclerosis: replicating Internet intervention effects using objective and self-report outcomes. *J Rehabil Res Dev*, 2011; 48(9):1129-1136
12. Dlugonski D, Motl RW, Mohr DC, Sandroff BM. Internet-delivered persons with multiple sclerosis: Sustainability and secondary outcomes. *Psychology, Health Med*, 2012; 17(6):636-651
13. Doerksen SE, Motl RW, McAuley E. Environmental correlates of physical activity in multiple sclerosis: A cross-sectional study. *Int J Behav Nutrition Physical Activity*, 2007; 4:49-55
14. Ellis T, Boudreau JK, DeAngelis TR, Brown LE, Cavanaugh JT, Earhart GM et al. Barriers to Exercise in People With Parkinson Disease. *Phys Ther*, 2013; 93(5):628-636
15. Erickson KI, Kramer AF. Aerobic exercise effects on cognitive and neural plasticity in older adults. Br J Sports Med, 2009; 43(1): 22-24
16. Fertl E, Doppelbauer A, Auff E. Physical activity and sports in patients suffering from Parkinson's disease in comparison with healthy seniors. *J Neural Transm*, 1993; 5:157–161
17. Goodwin VA, Richards SH, Taylor RS, Taylor AH, Campbell JL. The effectiveness of exercise interventions for people with Parkinson's disease: a systematic review and meta-analysis. *Mov Disord*, 2008; 23(5):631-640
18. Gosney JL, Scott JA, Snook EM, Motl R.W. Physical Activity and Multiple Sclerosis: Validity of Self-Report and Objective Measures. *Family Community Health*, 2007; 30(2):144-150
19. Logroscino G, Sesso HD, Paffenbarger RS Jr, Lee I-M. Physical activity and risk of Parkinson's disease: a prospective cohort study. *J Neurol Neurosurg Psychiatry*, 2006; 77:1318-1322.
20. Logroscino G, Sesso HD, Paffenbarger RS Jr, Lee I-Min. Body Mass Index and Risk of Parkinson's Disease: A Prospective Cohort Study. *Am J Epidemiol*, 2007; 166 (10):1186-1190
21. Marras C, Rochon P, Lang AE. Predicting motor decline and disability in Parkinson disease: a systematic review. *Arch Neurol*, 2002; 59:1724–1728
22. McAuley E, Motl RW, Morris K.S. et al. Enhancing physical activity adherence and well-being in multiple sclerosis: A randomised controlled trial. *Mult Scler*, 2007; 13:652–659
23. Motl RW, McAuley E, Snook EM. Physical activity and multiple sclerosis: a meta- analysis. *Mult Scler*, 2005; 11:459–463
24. Motl RW, Snook EM, McAuley E, Gliottoni RC. Symptoms, selfefficacy, and physical activity among individuals with multiple sclerosis. *Research Nursing Health*, 2006; 29(6):597-606
25. Motl RW, Snook EM, McAuley E. et al. Correlates of physical activity among individuals with multiple sclerosis. *Ann Behav Med*, 2006; 32(2):154-161
26. Motl RW, McAuley E, Doerksen S et al. Preliminary evidence that self-efficacy predicts physical activity in multiple sclerosis. *Int J Rehabil Res*, 2009; 32(3):260-263
27. Motl RW, Dlugonski D, Suh Y et al. Accelerometry and its association with objective markers of walking limitations in ambulatory adults with multiple sclerosis. *Arch Phys Med Rehabil*, 2010; 91(12): 1942-1947
28. Motl RW, Dlugonski D, Wójcicki TR et al. Internet intervention for increasing physical activity in persons with multiple sclerosis. *Mult Scler*, 2011; 17(1):116-128
29. Motl RW, Goldman M. Physical inactivity, neurological disability, and cardiorespiratory fitness in multiple sclerosis. *Acta Neurol*, 2011; 123(2):98–104
30. Motl RW, Gappmaier E, Nelson K, Benedict RH. Physical activity and cognitive function in multiple sclerosis. *J Sport Exerc Psychol*, 2011; 33(5):734-741
31. Motl RW, McAuley E, Wynn D, Sandroff B, Suh Y. Physical activity, self-efficacy, and health-related quality of life in persons with multiple sclerosis: analysis of associations between individual-level changes over one year. *Qual Life Res*, 2013; 22(2):253-261

32. Ng AV, Kent-Braun JA. Quantitation of lower physical activity in persons with multiple sclerosis. *Med Sci Sports Exerc*, 1997; 29(4):517-523
33. Nieuwboer A, De Weerdt W, Dom R, Truyen M, Janssens L, Kamsma Y. The effect of a home physiotherapy program for persons with Parkinson's disease. *J Rehabil Med*, 2001; 33:266–272
34. Nortvedt MW, Riise T, Maeland JG. Multiple sclerosis and lifestyle factors: the Hordaland Health Study. *Neurol Sci*, 2005; 26:334-339
35. Opara J. Fizjoterapia w chorobie Parkinsona. *AWF Katowice* 2014
36. Opara J, Kucio C, Socha T, Szczygieł J. Role of physical activity in preventing disability in Multiple Sclerosis. *Rehabil Med*, 2012; 16(2):34-46
37. Opara J, Małecki A, Mehlich K, Szczygieł J. Role of physical activity in preventing disability in Parkinson`s disease. *Rehabil Med*, 2013; 17(2):18-22
38. Opara J. Nowoczesna rehabilitacja w stwardnieniu rozsianym. rozdz. w monografii pod redakcją J Losy: Stwardnienie rozsiane. *Czelej*, Lublin 149-177; 2013
39. Opara J (ed). Problems of rehabilitation in multiple sclerosis. *AWF Katowice* 2013
40. Opara J. Rola aktywności fizycznej i umysłowej w zapobieganiu otępieniom. w: (red.) J Leszek. Choroby otępienne. Teoria i praktyka. *Continuo*, Wrocław 443-454; 2011
41. Petajan JH, White AT. Recommendations for physical activity in patients with multiple sclerosis. *Sports Med*, 1999; 27:179-191
42. Post B, Merkus MP, de Haan RJ, Speelman JD; CARPA Study Group. Prognostic factors for the progression of Parkinson's disease: a systematic review. *Mov Disord*, 2007; 22:1839-1851
43. Poulton NP, Muir GD. Treadmill training ameliorates dopamine loss but not behavioral deficits in hemi-parkinsonian rats. *Exp Neurol*, 2005; 193:181-197
44. Ridgel AL, Kim CH, Fickes EJ, Muller MD, Alberts JL. Changes in executive function after acute bouts of passive cycling in Parkinson's disease. *J Aging Phys Act*, 2011; 19(2):87-98