ESTIMATION OF POSTURAL STABILITY OF A PATIENT WITH MULTIPLE SCLEROSIS DURING A REHABILITATION PROGRAM - CASE STUDY

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Abstract

Background and purpose: *Multiple sclerosis (MS) is a demyelinating disease, usually with multifocal symptoms and multiphasic course that is emerging as a result of inflammation and the formation of foci of myelin breakdown in the central nervous system as a consequence of not fully known harmful external factors. The aim of this study was to analyze the results of tests allowing to detect imbalances in patients with multiple sclerosis.*

Material and Methods: *A 38 year old male with MS diagnosed in 2006 was examined. The study used three tests of balance: "Timed Up & Go" test, Tinetti test and Berg Balance Scale. The results of the scale were analyzed, which consisted in a variety of motor tasks assessing balance and gait. Tests were repeated every month for 10 months.*

Results: *The results in each test over 10 months significantly change. Changes in response to the increase of the number of tasks and the difficulty of the test occured. As a consequence of impaired balance control, the number of falls increased.*

Conclusions: *The stability of the patient with multiple sclerosis is getting worse in each test evaluated. The deficit of stability increased in response to increasing the number of tasks and increasing the difficulty of the test. A key role in postural stability in standing plays the pelvis and lumbo-pelvic-hip complex.*

Keywords: Multiple sclerosis, balance tests, lumbo-pelvic-hip complex, physiotherapy

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Introduction

Multiple sclerosis MS is a demyelinating disease, usually with multifocal symptoms and multiphasic course that is emerging as a result of inflammation and the formation of foci of myelin breakdown in the central nervous system as a consequence of not fully known harmful external factors [1].

The pathologic basis of the disease is the primary damage to the myelin in the CNS, but recently the role of axonal damage is emphasized. After exclusion of other diseases that might mimick the clinical picture, MS is diagnosed according to the dissemination of neurological symptoms in time and space, which means the presence of neurological symptoms caused by diffuse lesions in the CNS at different periods of time (with the exception of a minority of primary progressive cases). The new appearance of neurological symptoms is called „Relapse". Multiple sclerosis can have a considerable diverse course concerning frequency of relapses and the rate of progressing neurological deficit [2].

About 2.5 million people worldwide suffer from multiple sclerosis [3].

The incidence of the disease in Central Europe is estimated to be 83/100 000 of the population, women are more likely to suffer

from it than men [4]. The disease occurs in young people, usually begins between the 20th and 40th year of age, although there have been cases of children and old people [5].

Development of knowledge about the immune phenomena in human pathology contributed to advances in the treatment of MS. The pathogenetic mechanism is closely related to an autoimmune process, but still the causal etiology of the disease is unknown. With the increase of clinical trials and research new information about both the disease and the patients' life is provided [6].

Presently the most accepted hypothesis is autoimmune but the primary factor in triggering a cascade of phenomena remains unknown (virus?). An important role is played by T cells that are activated against the antigen of basic myelin protein. They pass the blood - brain barrier and penetrate into the nervous system [5]. Myelin damage occurs not only in the reaction of the antigen – antibody but probably due to the release of cytokines, mostly tumor necrosis factor TNF alpha by T cells. Demyelination is accompanied by an inflammatory process [5].

Three theories of the formation of MS are considered: the viral theory where the initiating factor is a pure viral infection; immune theory in which the presumptive viral agent initiates the disease and triggers an immune process; genetic factor - the inheritance of a particular particle of main human histocompatibility complex -human leukocyte antygen HLA, HLA-DR2 in particular which is related to a 4 times higher occurence of the disease than the other types of HLA. It is believed that HLA - DR2 can efficiently present an antigen of the autoreactive myelin sheath to T cells [7].

The most common form in adults is primary progressive (PP-) MS, in which relapses are missing, wheras the progression of symptoms is constant. The rate of progression in PP-MS is quite varied but in some cases of late-onset the prognosis tends to be poor. [2,8]. On average after a period of 5 - 7 years untreated MS takes the form secondary progressive (SP-) MS where relapses disappear and there is a constant neurological deterioration [2,8].

RR-MS is in 80% of cases the initial course of the disease and is characterized by the appearance of early neurological symptoms as relapses or worsening of the existing ones. In the period between relapses symptoms may disappear completelyor remain, but do not have a tendency to exacerbation. On average relapses occurs 1-2 times per year in untreated MS. Still it is important to pay attention to the individual course of the disease because the relapses may occur several times a year or not occur at all resulting in long periods of remission [2,8].

Due to the varied dynamics of the disease which causes damage to the central nervous system in many areas at different times the symptoms of MS are very different.

Neurological symptoms occurring in patients with MS are interindividually different because the lesions occur in different regions of the brain and spinal cord. The most common neurological symptoms in MS are pyramidal or sensory symptoms [2].

Paresis in MS is spastic. In neurological examination excessive tendon reflexes and pathological pyramidal signs are observed. Initially patients often complain of increasing limb weakness (usually predominantly in the lower limbs) after prolonged movement, so the patient needs to make breaks during walking [2].

Gait in patients with MS is diverse, shows a number of pathological elements depending on the types of paralysis, age and other factors. The complexity of balance control is observed in case of disorders caused by disease or aging. The balance control disorders cause postural instability which can lead to falls. The report of the Kellogg international group (1987) cataloged over a hundred different causes of balance loss. Among them the largest group was caused by neurological disorders impairing biomechanics of the body [10].

Balance is a certain state of the postural system. This condition is characterized by vertical orientation of the body achieved by balancing the forces acting on the body and their torques. Balance is provided by the nervous system, the appropriate tension of postural or anti-gravity muscles. Equilibrium describes the state of the locomotor system in static conditions. However, you can easily extend the concept to dynamic equilibrium situations. During locomotion typical vertical orientation of the head and body is maintained by phasic muscular activity [10].

The equilibrium is a much wider concept. It specifies the dynamic changes needed for restoring the proper body position disturbed by interfering stimuli [10]. The cause of these disturbances may be the own physical activity of the body, the variability of the environment or external forces arising from the interaction between the body and the external environment. Therefore it can be assumed that stability is a way of "resistance" to the destabilizing factors mentioned above [11]. The concept of stability refers to the smooth functioning of the musculoskeletal system, decision-making, analysis of the condition of the body at any given time and the reaction rate [12]. Stability changes as the position of the center of mass changes while performing the movement. The nervous system controlling the movement should provide postural stability. The trunk controls postural stability, it performs anticipatory postural corrections before the basic movement. An important function during locomotion plays the pelvis, which is a link between the trunk and the lower limbs. From the biomechanical point of view the pelvis, which carries the weight of the upper body, should be considered together with the lumbar section of the spine and hips. The fundamental role of the body has a lumbo-pelvic-hip complex. The pelvis bears the weight of the body, and the spine rests on the basis of the sacrum and hips. Small instability could disrupt the sacrum, hips and thus the body biomechanics and balance.

Disorders of integration of one of the components of this complex, including the musculofascial structures, nervous and musculoskeletal system itself will cause the formation of joint instability of the lumbo-pelvic-hip complex. A similar conclusion is

reached by Panjabi who presented a model of stability of the lumbar complex. Some call this model - a model of pelvic stability [23]. The stability of the trunk, pelvis or another joint is incorrectly understood as "good tight muscles." Stabilization is the "syncronization" between muscle groups: antagonists and agonists, and their "harmonization" with bone, joint and ligament system. The nervous system is the master of control in regulating other systems. However lack of information from the control system triggers a whole cascade of trophic changes in the tissues and joints. The fact that we move is a result of the stability of the entire Panjabi's model. Some muscle groups need to stretch, the other at the moment work eccentricly, isotonicly or otherwise [23].

During normal gait the pelvis moves asymmetrically in three dimensions. All movements of the pelvis during gait are small. In the frontal plane the pelvis falls and rises in the range of 7 degrees. In the sagittal plane it reaches 4degrees of anterior and posterior tilt. In the transverse plane the pelvis rotates to the right and left in about 10 degrees. [24]. Just before the initial contact of the heel with the ground the pelvis in the frontal and sagittal plane is set in the neutral position, in transverse plane is rotated about 5 degrees in direction of the supporting leg. The tension of posterior thigh muscle groups grows. Contraction of the biceps femoris causes tension of the sacrotuberous ligament, contributing to extension of the forced locking mechanism. The acquisition of weight by the limb changes the setting of the pelvis in all three planes. It is related to the amortization function. During the phase of support on the right leg the pelvis is rotated to the right, it moves forward and abducts towards the right femur. The right pelvic bone turns forward, the left turns back, the sacrum rotates to the left [25]. During the swing phase the whole pelvis moves on the femor heads in the transverse plane, in the direction of the loaded leg. The result is that the range of motion required for the hip is reduced in flexion and extension. At the same time the pelvis abducts on the loaded leg, it reduces the peak of vertical elevation of the center of mass. If the swing phase is on the right the pelvis rotates to the left, moving to the front and abducting towards the left femur head (as a whole moves to the right in the frontal plane). At the same time the right pelvic bone rotates backward, the left one rotates forward. The sacrum rotates to the right. The sacrotuberus ligament and sacroiliac interosseus ligament tighten, which is the preparation to the initial contact phase. The increase in tension increases the compression and stability. The cycle repeats [24].

Observing the posture of a patient with multiple sclerosis it often seems as if the back muscles are not able to maintain an upright position and thus the spine is placed in one hump. In fact the passive sitting position is disturbed by an unbalanced stabilization mechanism – the so called internal stabilization muscle complex. Stable and active sitting means the integration of abdomen muscles - rectus and transversus - with the pelvic muscles, diaphragm and multifidius [25].

Impaired integration of one of the determinants leads to not active sitting. After the trauma (external or internal) the body produces spontaneously a locomotion mechanism which is different from the physiological pattern. Studies on the function of the lumbo-pelvic-hip complex showed that each element in the system is integrated functionally.

According to the Panjabi's stability model, dysfunction of one of the stabilizing subsystems causes compensating changes in the others which can lead to development of symptomatic dysfunction of the weakest link of the complex [26].

Maintaining stable standing position becomes possible through the active co-operation of the control system of the three sensory inputs [13,10,11].

The main task of the control system is to maintain an optimal distance of the center of mass from the edge of stability and to resist destabilizing external forces. Responsible for that is the peripheral control system that allows maintaining both static and kinetic sense of balance and spatial orientation of body parts [11,14,15].

Postural response of the body exposed to disturbance of equilibrium is compared by many authors to movements of the inverted pendulum [16].

Nashner (1993) identifies three strategies to control the balance which are required to keep the center of mass in the plane of the support.

The first one - ankle strategy - occurs when a person is standing on the platform (wider than the plane of support), exposed to short external disturbances forward and backward. Forward movement triggers gastrocnemius muscle tension, the body leans backwards, the opposite movement triggers the tibialis anterior muscle combined with bending the body forward. The rotation axis in this strategy is the ankle.

The second is the strategy of the hip. A person is on the equivalent platform. Moving backward the trunk bends forward with flexion of the hip. This strategy uses more flexion and extension in the hip.

The third is step strategy which is activated when the external force is moving the center of mass outside the plane of suport. To defend from falling the patient makes a step [16,17].

Therefore in the study a patient with multiple sclerosis was analized using balance assessment scales.

Case

Patient X. X (age 38) since 2001 was feeling constant fatigue and sleepiness. The patient was diagnosed as manic - depressive. Until March 2006 he was under psychiatric treatment and observation for depression. In April of the same year the patient noted fatigue and weakness in lower limbs after rest. A month later in the mornig the man could not get up because of poor sensation in the lower limbs. After the incident he was referred to a neurologist who ordered an MRI which was performed 2 months later. In August 2006 he was admitted to the hospital with increased spasticity of the lower limbs. After another MRI MS was diagnosed. The patient was hospitalized for two weeks and treated with Betaferon. However, after this

time there was no improvement. The patient was discharged with increased spasticity of the lower limbs. After 8 months on Betaferon there was no improvement so the medication was switched to Tysabri for another 10 months. Despite this the drug did not bring positive results.

In the course of Tysabri the patient was hospitalized during exacerbations. Neurological examination revealed spastic paresis of the lower extremities with bilateral positive Babinski-signs. Alumbar puncture was performed. In a study of cerebrospinal fluid(CSF) oligoclonal bands were detected.

Since 2010 theweakness in the legs was more intense and there was a significant spasticity. Currently the patient moves in a wheelchair, at home with difficulty with a walker. Since the first incident there were no relapses, but the patient complained of progressive weakness of the lower limbs and gait disturbances.

Results

Three tests were carried out to examine the balance and locomotion within 10 months (before and after rehabilitation).

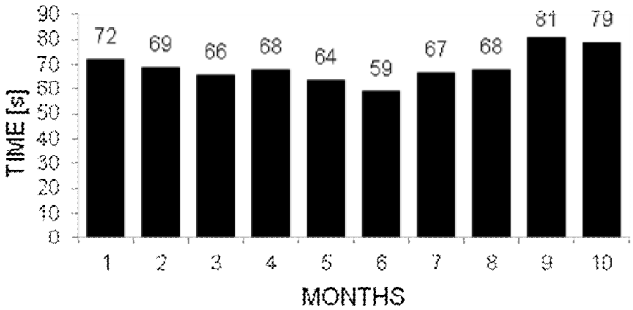

Fig. 1 Results of Timed up & go test. Initially it is observed increasing improvement of balance (up to 6th month), and then decrease which is noticed through an increase of times

The "TIMED UP & GO" test was carried out 10 times, every month. At the first measurement the time was 72''. After 6 months of rehabilitation it was reduced to 59'', the time improved by 13''. The last result was 79''. The most significant difference of time was registered between the sixth and tenth measurement (20''). Initially increasing improvement of balance is observed (up to the 6th month), and then a decrease which is noticed by an increase of times.

Tab. 1 Berg Balance Scale test results. Very clear is the disparity of results between 5th and 9th month where the difference is 15 points

Month/tasks	1	2	3	4	5	6	7	8	9	10
1	2	3	2	3	2	3	0	3	1	2
2	4	4	4	4	4	4	4	4	4	4
3	4	4	4	4	4	4	4	4	4	4
4	3	3	3	4	4	4	4	3	3	3
5	2	2	3	3	3	3	3	3	3	2
6	0	2	3	3	3	3	3	3	0	2
7	0	2	3	2	4	4	2	4	0	2
8	2	2	3	3	4	2	3	2	2	2
9	0	0	0	0	0	0	0	0	0	0

10	1	2	3	4	4	3	4	4	0	2
11	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
SUM:	**18**	**24**	**28**	**30**	**32**	**30**	**27**	**30**	**17**	**23**

The Berg Balance Scale Test was performed every month for 10 times. The first result was 18 points which means that the patient is dependent on a wheelchair. From the 2nd to 5th month there are clear increases in points, in the 5th month the highest score of 32 points was recorded. This means that the balance of the patient improved and he could move with walking aids. From the 6th month, for three following months an obvious drop in points was noted. Very clear is the disparity of results between the 5th and the 9th month, where the difference is 15 points (32-17).

The last test by which the patient has been evaluated is the Tinetti Test. This test consists of two parts: the first one is a balance evaluation, and the second one a gait - evaluation. After each of these tests the points are summarized, the onerall sum determines the stability in standing and sitting. The patient's results from the first part are not commensurate with the results from the second part. This difference results from the fact that the patient maintains the balance only with difficulties while standing.

Tab. 2 Tinelli Test results

	Balance reaction									
Month/task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1
3	2	2	2	2	2	2	2	2	2	2
4	2	2	2	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	1	0
6	1	1	1	1	1	1	1	1	1	1
7	0	0	0	0	0	0	0	0	0	0
8	0	0	2	2	0	0	0	0	0	0
9	0	0	1	1	0	1	1	1	1	1
SUM:	**7**	**8**	**10**	**8**	**5**	**6**	**6**	**6**	**7**	**6**

Analyzing the first point of the first part (assessing the balance), a rise of 1 point until the 3rd month is noticed, then a decline in the fourth month, and after that period it balance remains stable. The patient received the highest result in the 3rd month (10 points), the lowest in the fourth (5 points).

Considering the results of the second part they are arranged in a sinusoidal manner. At the first measurement the result was highest (3 points), then it declined (2nd month), in the third month it raises again. This tendency of the pendulum stays until the end of the study (10 months). Summing up the overall result of the test (the two parts) it is noticed that the most significant difference was at 6 points (score of the 3rd and 8th month) and the lowest at 2 points (between the first and third month). In the first month the patient received 10 points, finishing the study (10th month) with 7 points.

Summing up the results of the three tests it may be concluded that in the early months the patient improved his balance, and then deteriorated. The deficit of stability increased with impeding and increasing the number of tasks in the test. The process of rehabilitation of patients with MS is an essential component of their treatment. The scales used in the study show the state of mobility and changes in the balance which refer to the variability of the disease in time.

Discussion

To evaluate the balance of patients with MS one can use a variety of scales. The tests to evaluate the functional gait and balance that were applied were the Timed Up & Go test, the Berg balance scale and the Tinetti test. TheTimed Up & Go test is used to measure the time of getting up from a sitting position on a chair, going three meters, rotating 180 degrees, returning and siting down without any help. The authors of the test, Podsiadło and Richardson, also proposed this test with a distance of 10 meters. Less complicated is the 10 or 20 meter test. The time to walk that distance is measured and the speed of walking is calculated accordingly [18]. Another method of assessing the balance is a test of two scales where the load of the lower limbs is measured. In normal conditions the limbs are balanced with the possible deviation of 4 to 5 kilos. The symmetry rate of the load of the limbs as a ratio of greater to lesser load is evaluated(Kwolek). The proper rate is in the range of 1.00 to 1.15 [19].

One more clinimetric scale was taken in account in the study: theTinnetti Scale, which has two components to be evaluated, balance and gait. This scale examines the difficulties with walking and locomotion, assesses the severity of the disorder and identifiesbalance or gait parameters that are impaired. It can also be used to predict the risk of falls in elderly people.

In these studies each clinimetric method of assessment examines a single function. The study shows beneficial effects of considering both single functions and a holistic approach to the patient's fitness.

The study analyzed stages of rehabilitation in a patient with MS. This patient performed three tests to determine the balance and locomotion which were carried out within 10 months (before and after rehabilitation). After 5-6 months of rehabilitation the difficulty with balance shown in the "Timed Up & Go" test and the Berg balance scale decreased. The improvement shows the effectiveness of rehabilitation in

MS. Improving balance is associated with the improvement of physical independence. Independence in everyday life becomes meaningful to humans when it starts deteriorating, as in MS. The disease slowly changes the patients' life. After analyzing the results the effectiveness of rehabilitation was confirmed, Romberg and colleagues [20] compared the efficiency of walking in patients who were rehabilitated regularly for 6 months and patients who have not been rehabilitated. The results clearly indicated that mobilized patients were able to pass quickly both short (7.62 m) and long distances (500 meters). In the rehabilitated group 22% after 6 months were able to pass the distance of 7.62 m significantly quicker.

Freeman [21] in a prospective study of 60 patients, who were rehabilitated for 25 days, noticed a decrease in disability, lasting up to 6 weeks after rehabilitation.

Other studies point to the persistence of improvement after performing rehabilitation, but also an interesting phenomenon has been observed - discrepancy between positive self-esteem of the patient and the objective result of deteriorating neurological condition, documented by such scales as the EDSS [22].

Currently a number of studies are being carried out to assess the physical activity, balance and quality of life of patients with MS. The rehabilitation program of patients with MS is a necessary part of the entire therapy. The benefits of the rehabilitation are essential and fully complement the drug therapy in patients with MS.

Resumo

Fono kaj celo: Multobla Sklerozo (MS) estas senmjeliniga malsano, kutime kun multfokusaj simptomoj kaj multfaza sinsekvo, kiuj rezultas el inflamo kaj ekesto de fokusa mjelina rompiĝo en la centrala nerva sistemo kaŭze de ne komplete konataj malutilaj eksteraj faktoroj. La celo de tiu ĉi esploro estis la analizo de resultoj de testoj, kiuj eblas malkovri neekvilibrojn en pacientoj kun MS.

Materialoj kaj metodoj: 38 jaraĝa malsanulo kun MS, kiu estis diagnozita en la jaro 2006 estis ekzamenita. La esploro uzis tri diversajn testojn de korpa ekvilibro: la "Timed Up & Go"-teston, la Tinetti-teston kaj la Berg-ekvilibro-skalon. La rezultoj de la skaloj, kiuj konsistis el variantoj de motoraj taskoj, kiuj ekzamenis korpan ekvilibron kaj irmanieron, estis analazitaj. La testoj estis ripetataj monate dum dek monatoj.

Resultoj: La resultoj de ĉiu testo dum la dek monatoj konsiderinde ŝanĝiĝis. La ŝanĝoj okazis responde al la pliigo de la nombro de la testoj kaj ilia malfacileco. Kiel sekvo de la nenormala kontrolo de la korpa ekvilibro, la ofteco de faloj plialtiĝis.

Konkludoj: La stabileco de la MS-paciento malpliboniĝas en ĉiu esplorita testo. La manko de stabileco plialtiĝas depende de la nombro de la taskoj kaj la malfacileco de la testo. Centralan rolon en la postura stabileco dum staranta pozicio ludas la pelvo kaj la lumba-pelva-koksa komplekso.

References

1 R. Mazur, W.Kozubski, A.Prusiński: Podstawy kliniczne neurologii dla studentów medycyny. Wyd. Lekarskie PZWL. Warszawa. 1998, s. 259-268

2 Selmaj K.: Stwardnienie rozsiane: Kryteria diagnostyczne i naturalny przebieg choroby. Polski przegląd neurologiczny. 2005; 1,3: 99-106

3 Compston A, Coles A. Multiple sclerosis. Lancet 359 (9313), 1221-1231 (2002)

4 Pugliatti M, Rosati G, Carton H et al. The epidemiology of multiple sclerosis In Europe. Eur. J. Neurol. 13(7), 700-722 (2006)

5 A.Prusiński.: Neurologia praktyczna. Wyd. Lekarskie PZWL. Warszawa, 1998, s. 310-315

6 Selmaj K.: Stwardnienie rozsiane. W: Wprowadzenie. Definicja i historia. Terme-

dia wydawnictwo Medyczne. Poznań, 2006, str. 5-9
7 Alperovitch A., Berr C., Cambon – Thomsen Ai WSP: Viral antibody titers, immunogenetic markers, and their interrelations In multiple sclerosis patients and controls. Hum. Immunol. 1991; 31: 94-99
8 Selmaj K.: Stwardnienie rozsiane. W: Naturalny przebieg SM. Termedia Wyd. Medyczne. Poznań, 2006' str. 68-81
9 A.Szczeklik.: Choroby wewnętrzne. Medycyna praktyczna. Kraków, 2006, s. 1943-1948
10 Błaszczyk J.: Biomechanika kliniczna. Wydawnictwo Lekarskie PZWL. Warszawa, 2004, s. 192-265
11 Błaszczyk, J.W., Czerwosz, L. (2005) Stabilność posturalna w procesie starzenia. Gerontologia Polska, Vol. 13 (1), 25-36
12 Kuczyński, M. (2003) Model lepko- sprężysty. Studia i Monografie. Wrocław: AWF, 7-55
13 13. Mańko G, Butelska A, Zyznawska J (2012) Znaczenie stabilnej miednicy i Kompleksu Panjabi'ego w kontroli stabilnej postawy stojącej. Medycyna Manualna, Tom 16, Nr 4, 30-34
14 Nowicki, J. (2004) Rola narządu przedsionkowego w układzie równowagi fizycznej ciała. Polski Przegląd Medycyny Lotniczej, 2(10), 121- 133
15 Ocetkiewicz, T., Skalska, A., Grodzicki, T. (2006) Badanie równowagi przy użyciu platformy balansowej- ocena powtarzalności metody. Gerontologia Polska, Vol. 14 (1),144-148
16 Nashner, L.M. (1993) Practical biomechanics and physiology of balance. Cyt. w: Jacobson, G.P., Newman, C.W., Kartush, J.M. (eds.) (1993) Handbook of balance function testing.261-279
17 Held-Ziółkowska, M. (2006) Równowaga statyczna i dynamiczna ciała. Część 1: Organizacja zmysłowa i biomechanika układu równowagi. Magazyn Otorynolaryng., tom V, z. 2 (18), 39-47
18 Podsiadło D., Richardson S.: The Timed „Up&Go"a test of Basic functional mobili ty for frail elderly persons. Geriatr.Soc 1991, 39, 142
19 Kwolek A., Kluz D.: Test dwóch wag w ocenie stopnia zaburzeń i postępu usprawniania u chorych z niedowładem połowiczym po udarze mózgu, Post. Reh.,1991 5 (2), 89
20 Romberg A, Virtanen A, Ruutiainen J i wsp. Effects of a 6-month exercise program on patients with multiple sclerosis: a randomized study. Neurology 2004; 63: 2034-8
21 Freeman JA, Langdon DW, Hobart JC i WSP. The impast of inpatient rehabilitation on progressive multiple sclerosis. Ann Neurol 1997; 42: 236-44
22 Kidd D, Thompson AJ. A prospective study of neurorehabilitation In multiple sclerosis. J Neurol Neurosurg Psychiatry 1997; 62: 423-424
23 http://fizjoartis.pl
24 Perry J.: „ Gait Analysis: Normal and Pathological Function". Slack Inc 1992
25 Lee D.: Obręcz biodrowa. Badanie i leczenie okolicy lędźwiowo – miedniczno – biodrowej, Db Publishing, 2001, s.57-84
26 Gnat R., Saulicz E., Kuszewski M.: „Zaburzenia funkcjonowania systemów stabilizacyjnych kompleksu biodrowo – miedniczno - lędźwiowego".„Fizjoterapia", 2006,14,3, 83-91