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Physical Activity in Finnish Persons with Multiple Sclerosis

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Abstract

Background: Given the long-term progressive nature of multiple sclerosis (MS), it is associated with reduced physical activity. The use of different measurement methods may, however, yield differing results on actual physical activity levels in persons with the disease. The purpose of this study was to examine free-living physical activity in persons with mild and moderate MS and to compare it with that of sedentary healthy control persons.

Materials and methods: The study applied a cross-sectional design. Ambulatory (Expanded Disability Status Scale scores between 0 and 5.5) persons with MS (n=22) and sex- and age-matched, mostly sedentary, healthy control subjects (n=20) took part in the study. Physical activity was measured with an accelerometer and a pedometer during the waking hours of a 7-day period. After the period the participants completed a 7-day recall physical activity questionnaire.

Results: Physical activity was reduced in persons with MS as compared to the healthy only as assessed by a pedometer (*P*=0.01), but not by an accelerometer (*P*=0.90) or a questionnaire (*P*=0.63).

Conclusions: Levels of habitual physical activity in MS vary depending on the measure used. Compared to mostly inactive healthy subjects, ambulatory persons with MS may be equally physically active.

Introduction

There is incontrovertible evidence for the positive effects of regular physical activity on different aspects of health [1]. Also in persons with multiple sclerosis (MS) physical activity produces benefits e.g. in fatigue, mobility, and quality of life [2-4]. For them ongoing participation in physical activity may induce positive effects lasting over years [5, 6].

According to a meta-analysis physical activity is reduced in persons with MS as compared to the healthy [7]. More recent research suggests that the degree of physical inactivity is less than previously reported [8]. Nonetheless, there exist notable variations in physical activity levels. One study showed lower activity in persons with MS compared with healthy control subjects as measured with an objective method but not when applying a questionnaire [9]. Another survey study reported that 68% of women with MS met the Behavioural Risk Factor Surveillance System (BRFSS) recommendations for regular physical activity. The respective number in general female population is 28% [10]. The use of step counts as an activity criterion yield that the average number of daily steps taken by persons with MS in one study [11] may be twice as high as in another [12]. Likely, a number of factors lie behind the disparities in the physical activity patterns. Measurement methodology, the features of comparison groups, levels of neurological impairment as well as disability must be considered when examining physical activity patterns in MS [7,13,14].

By definition, physical activity means any bodily movement produced by skeletal muscles which results in energy expenditure [15]. It can be assessed either indirectly or directly. Self-report questionnaire is the most frequently used indirect method, but many of them yield neither reliable nor valid information [16]. Motion sensors, such as pedometers and accelerometers, are examples of a direct method. The pedometers used to assess physical activity in neurological conditions are prone to be inaccurate [17]. The advantage of accelerometry is that it can provide versatile information about the amount, frequency, intensity, and duration of physical activity in daily life [18]. Of the commercially available accelerometers, tri-axial versions may provide a more comprehensive estimate of non-ambulatory and sedentary activities than the uni-axial ones [19].

Tri-axial accelerometer has been shown to be a stable and reliable measure for free-living physical activity in a variety of neurological diseases [20]. In MS in particular, it is able to differentiate active persons from those who are inactive [21]. In one study accelometry was more associated with walking mobility than physical activity in persons with MS [22]. However, the placement of an accelerometer may have an influence on results in persons with mobility impairments, but there exist no consensus about the optimal practice [19, 20, 23].

The actibelt® is a newly developed, wearable clothing belt containing a tri-axial accelerometer integrated into its buckle. It is capable to monitor continuously, unobtrusively long-term physical activity–including running, walking, standing, sitting or lying–in the course of daily life [24]. The actibelt® parameters can be divided into basic and extended categories. Basic category parameters like activity count; activity level and activity temperature can be calculated for everybody independently of the existence of a disease. Extended category parameters like for instance active speed, number of taken steps, distance travelled, and coherence length are more complex ones and require sometimes individualized calibration for taking disability into account.

The purpose of this study was to examine habitual physical activity of Finnish persons with mild and moderate MS and to compare it with that of sex- and age-matched healthy control persons. Physical activity was assessed comprehensively using two direct methods (the actibelt®

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and a pedometer), and indirectly using a questionnaire. The results obtained with different measures were compared against each other.

Materials and Methods

Participants

A convenience sample of subjects with MS participating into inpatient rehabilitation programs at the Masku Neurological Rehabilitation Centre (Finland) was recruited.

The inclusion criteria were a confirmed diagnosis of MS [25], a score of 0 to 5.5 on the Expanded Disability Status Scale (EDSS) [26], relapsing–remitting or secondary progressive MS, and age between 25 and 55 years. The exclusion criteria were a relapse during a preceding month, primary progressive disease course, any other disease likely to affect on physical activity, or signs of any other medical or mental condition precluding participation. The aim was to recruit at least 10 MS subjects with both mild (EDSS 0-3.0) and moderate (EDSS 3.5-5.5) disease.

The control group consisted of healthy volunteers matched to the MS participants' by sex and age. Control subjects were physically inactive, mostly office workers. Exclusion criteria included participation in vigorous pre-planned exercise at least 3×45 minutes per week and any other disease likely to affect physical activity. All study subjects signed an informed consent for their participation. The study was approved by the local Ethical Committee in South-Western Finland.

Physical activity measures

The actibelt® is a tri-axial accelerometer inside a buckle of a belt [24]. The sensors measure accelerations in anteroposterior, mediolateral and vertical directions. For the activity within one minute all three axes are combined and a mean value of acceleration over the whole minute, considering also gravitational forces, is calculated. This parameter in accelerometry based systems is called activity counts (AC), which is expressed in activity units (1 activity unit=1, g=9.81 m/s^2).

Activity Temperature is a parameter to characterize and measure mean overall activity over a period of time. As the activity temperature is intended to reflect how actively a person behaves in daily life it is only calculated if a minimum of activity counts of 6 hours are available. At this it is either determined for a single actibelt® record (lasting more than 6 hours) or for a whole calendar day. The activity temperature was averaged to 24 hours. Minutes for which activity count was unavailable were assigned a value of 0.

The actibelt® was attached around the participant's waist with the buckle positioned at the lap height close to the body's centre of mass. Participants were advised to wear the actibelt® during waking hours except when taking a shower, swimming or visiting a sauna. The device was worn for 7 consecutive days first during inpatient rehabilitation and thereafter for 7 days at home. The home measurement period started within less than one week after rehabilitation discharge. In order to prevent a total accelerometer battery failure, the subjects were given a USB cable to charge the battery (once) via USB port on their PC during sleeping time. Technical support via telephone was offered if necessary.

The Yamax SW-200 Digi Walker pedometer (Yamax Corporation, Tokyo, Japan) digitally displays step counts. The accuracy, reliability, and validity of the device in subjects with MS have been tested [27, 28]. Participants wore the pedometer over their right leg according to manufacturer's instructions for 7 consecutive days first during rehabilitation and then at home similarly as the actibelt®. Participants recorded their number of steps taken in a log.

The short form of the International Physical Activity Questionnaire (IPAQ) comprises six items measuring the frequency and duration of vigorous- and moderate-intensity activities and walking during the last 7 days [29]. Its validity in persons with MS has been tested [28]. The IPAQ scores are expressed as MET minutes/week. A categorical IPAQ score can be calculated to classify physical activity into three levels: high, moderate or low [30]. All study subjects responded to the IPAQ immediately once the 7-day measurement period had ceased.

Other measures

Participants completed the Rochester Fatigue Diary (RFD) during the 7 days they wore the motion sensors. RFD is a MS-specific measure to rate energy level on a visual analogue scale every hour for 24 hours [31]. The RFD was primarily used to compare the time of the participants' waking hours against the actibelt® on time recordings.

To assess walking capacity, a 6-minute walk test (6MWT) was carried out according to the guidelines of the American Thoracic Society [32] (with the exception of a practice test). The 6MWT is a feasible, reproducible, and reliable measure in MS [33]. Participants were instructed to walk as far as possible in a 30-m track marked by cones in a hallway. The actibelt® was worn during the 6MWT. To analyse temporal-distance gait characteristics, gait speed, step length and step frequency parameters were calculated using the actibelt® -data.

Statistical analysis

The analysis of the contingency tables was done with Fisher´s exact test for count data. For other group comparisons, the Wilcoxon's signed-ranked test was used due to the small sample size and because the assumption of normal distribution was not fulfilled. For within-group comparisons between the different measures of physical activity the Wilcoxon's matched pairs signed-ranked test was used. All statistical analyses were conducted using the software R 2.7.1.

Results

Twenty-two participants with MS and 20 healthy control persons were recruited for the study. Ten subjects with MS were classified to be mildly (EDSS 0-3.0) and 12 moderately (EDSS 3.5-5.5) disabled. One subject with moderate disability was excluded from all analyses owing to a MS relapse. The MS group differed from the control group in height, employment status and 6MWT distance. Subjects with mild and moderate MS showed similar characteristics except for the EDSS and the 6MWT distance (Table 1).

The results from the 6MWT on the temporal-distance gait parameters indicated that subjects with MS walked with reduced gait speed, decreased step length, and lower step frequency as compared to the controls (P<0.001 in all). These abnormalities were more marked in moderately disabled MS subjects.

All but two study subjects were recorded by actibelt® for 7 consecutive days. One participant with MS forgot to switch on the actibelt® for one day, one control person switched it off inadvertently for several hours. For them, the missing days were replaced with one extra recording day. This is an approved imputation technique to compensate for insufficient accelerometer data [34]. Analyses with/without these extra days showed no effect on the overall actibelt® results.

Variable	MS all (n=21)	MS mild (n=10)	MS moderate (n=11)	Controls (n=20)	P-value MS vs. controls	P-value MS mild vs. MS moderate
Sex (male/female)	9/12	3/7	6/5	9/11	1.0	0.39
Age (years)	43.7 ± 7.4	45.3 ± 5.8	42.3 ± 8.7	43.1 ± 6.8	0.66	0.60
Body dimensions						
Height (cm)	168.6 ± 8.2	165.6 ± 6.7	171.3 ± 8.9	174.4 ± 8.9	0.04	0.30
Weight (kg)	74.3 ± 10.5	74.1 ± 11.6	74.5 ± 10.1	76.0 ± 15.5	0.93	0.97
BMI (kg/m^2)	26.2 ± 3.6	27.0 ± 3.4	25.5 ± 3.8	24.8 ± 3.7	0.26	0.48
Employed	9	6	3	19	<0.001	0.20
Disease characteristics						
Disease course (RR/SP)	17/4	10/0	7/4	NA	NA	0.09
Disease Duration (years)	6.8 ± 5.1	5.6 ± 5.8	7.8 ± 4.3	NA	NA	0.30
EDSS	3.3 ± 1.1	2.3 ± 0.8	4.1 ± 1.3	NA	NA	<0.001
6MWT distance (m)	456 ± 143	569 ± 64	359 ± 118	646 ± 56	<0.001	<0.001

Abbreviations: BMI: Body Mass Index; RR: Relapsing-Remitting; SP: Secondary Progressive; EDSS: Expanded Disability Status Scale; 6MWT: Six-Minute Walk Test; NA: Not Applicable

Table 1: Demographic and clinical characteristics (mean ± standard deviation) of the study sample.

Measure	MS all	MS mild	MS moderate	Controls	P-value MS vs. controls	P-value MS mild vs. MS moderate
IPAQ (MET min/wk)	2803 ± 3831	4204 ± 5021	1529 ± 1707	2235 ± 1634	0.63	0.07
Pedometer (steps/day)	5738 ± 3232	7309 ± 2671	4309 ± 3124	8302 ± 2015	0.01	0.02
Actibelt parameters						
Steps/day	8291 ± 3289	9747 ± 2481	6471 ± 3397	9152 ± 2980	0.46	0.06
Time walked/week (min)	1406 ± 480	1427 ± 504	1376 ± 482	1176 ± 315	0.47	0.08
Activity temperature score	6.11 ± 1.5	6.20 ± 1.7	6.00 ± 1.4	5.91 ± 0.7	0.90	0.75

NOTE: Complete data (MS subjects, n=21; healthy controls, n=20) were registered for pedometer and the IPAQ. Acceptable Actibelt-data were recorded in 10 persons with mild MS, 8 persons with moderate MS, and in 18 healthy controls apart from total time walked/week, in which reliable data was recorded in 7 persons with moderate MS.
Abbreviation: IPAQ: International Physical Activity Questionnaire.

Table 2: Study participants' physical activity data (mean ± standard deviation).

The comparison between the RFD waking hours against the actibelt® on time recordings within each of the studied groups showed no significant differences. In four participants (three MS, one control), the amount of actibelt® recordings was less than the pre-set minimum of 6 daily hours of data. Moreover, in one control subject a reliable calculation of actibelt® parameters were not possible owing to problems in data acquisition. Therefore the analyses of the parameters mean daily steps and activity temperature were based on 18 MS, and 18 control subjects. The average amount of collected daily activity for these participants was 14 hours 59 minutes (MS subjects), and 14 hours 44 minutes (controls). Regarding total time walked/week the number of MS subjects considered was 17. One case was excluded because of the lack of recordings for 7 consecutive days, which are necessary for calculation of this parameter.

Table 2 shows the average physical activity of all groups as measured by the three methods. Significant group differences were only found for the pedometer data, i.e. healthy controls took daily more steps than persons with MS, and the group with mild MS more than the group with moderate disability. The step counts in the actibelt® data showed no differences between groups. The number of daily steps was higher as measured by the actibelt® than by a pedometer: MS all (P<0.001), MS mild (P=0.002), and controls (P=0.003) with the exception of the moderate MS group (P=0.08).

According to the IPAQ categorical score 6 subjects in the MS group were highly active, 10 moderately active, and 5 showed with low activity. The respective figures in the control group were 8, 9 and 3 (*P*=0.72 for difference between groups). In persons with MS difficulties in estimating the duration of activities for the IPAQ have been reported. Hence, the IPAQ total score was further analysed by omitting the data on duration of activity. The frequency of vigorous, moderate and walking activities were multiplied by fixed MET values and then summed to get a continuous measure of physical activity [28]. The recalculated IPAQ score in all MS subjects was 26.5 (SD 12.6), in the mildly disabled group 30.3 (SD 13.8), in the moderately disabled group 23.1 (SD 10.9), and in the healthy 33.7 (SD 14.9). The difference between subjects with MS and controls as well as that between the two MS groups were insignificant (*P*=0.11, and *P*=0.22 respectively).

Discussion

The present study examined habitual physical activity of Finnish persons with mild and moderate MS and compared the activity levels with those of healthy controls. The results indicated that physical activity in MS was reduced as measured directly by a pedometer (Yamax SW-200), but not by a tri-axial accelerometer (the actibelt®) or using an indirect recall questionnaire (the IPAQ). The comparisons between groups of mild and moderate MS yielded similar results in the activity levels.

Several reasons may explain our findings. Yamax SW-200 is probably the most widely used pedometer in physical activity research both in subjects with MS and in the healthy [11,27,28,35]. One study, however, reported that it may undercount when used for people with MS or other neurological conditions [17]. Particular concern has been raised about its measurement accuracy at slow walking speeds [27]. Our results on the 6MWT indicated a shorter walking distance and a number of abnormalities on the temporal-distance gait parameters in the MS group as compared to the controls. Additionally, according to clinical observations several of participants with MS showed with altered gait patterns such as shuffling or step asymmetry.

Gait abnormalities in persons with MS might pose problems for valid and reliable physical activity measurement not only by pedometers but also by accelerometers. Altered gait patterns, possibly combined with a use of an assistive device, may induce minimal vertical acceleration along the sensitive axis of an accelerometer leading to reduced number of movement counts. This, in turn, might cause a misinterpretation that the person is physically inactive albeit the accelerometer signal is reflecting impaired walking mobility [36]. The issue whether accelerometry provides a measure of physical activity, walking mobility, walking speed or all of them in MS has been addressed to at least in three studies. The uni-axial accelerometer movement counts have been found to correlate either strongly or moderately with the IPAQ, and strongly with self-report measures of walking mobility. The correlations led to conclude that accelerometry provides a measure of both physical activity and walking mobility among ambulatory individuals with MS [36,37]. Moreover, accelometer output has been found to correlate only with walking mobility measures but not with IPAQ in persons with MS [22]. Our results' are somewhat inconsistent with these reports because we were unable to show a correlation neither between the activity temperature and the IPAQ nor between the activity temperature and the 6MWT.

The activity temperature is a robust parameter to characterize the overall physical activity levels as measured by 3D-acceleration data. The calculation of the parameter accounts for both the duration and the intensity of the activity. This is of crucial importance in the measurement of physical activity in ambulatory MS subjects' because reduced temporal-distance gait parameters lead to compensation in the duration of the activity. Energy expenditure during walking has been reported to be higher in persons with MS compared with that of controls [38]. Higher energy expenditure combined with longer total walking time/week may well explain the lack of difference on the activity temperature between the MS and control group in our study.

It has been debated whether pedometers and accelerometers are more sensitive to detect differences in physical activity in MS populations than the indirect questionnaire method [7]. One controlled study, with MS sample resembling much that of ours (n=17, median EDSS 3.0), found reduced physical activity in MS as measured by a tri-axial accelerometer but not by the 7-Day Physical Activity Recall-questionnaire [9]. Our first choice to measure physical activity indirectly was the IPAQ because of its wide use and validity in both MS and healthy samples [11,28,29]. Nonetheless, it was unable to show group differences in physical activity levels.

The comparison sample may act as a moderating variable on the differential activity patterns [7]. Until recently, controlled field studies examining habitual physical activity in MS using objective methods have been characterised by a low number (n=8-11) of subjects with MS [12,19,39] or low number of control persons in relation to the MS sample [21,23]. To our knowledge, four studies have included sample sizes ≥ 15 for a group of MS subjects as well as controls [8,9,22,40]. Moreover, there exist notable variations in the predefined criteria for activity levels for the controls. In most cases sedentary healthy individuals have been included [9,20,39], but active healthy persons [21] or subjects with other diseases [12,40] have also formed the control group. Frequently, any preset criteria for the activity levels of the healthy controls have not been reported [8,12,22,23,40]. We believe our criteria for a relative inactive control group was well fulfilled. The controls subjects were mostly office-workers, engaged in <3×45 minutes/week in vigorous pre-planned exercise, and took on average 8302 steps/day as measured by a pedometer. For comparison, healthy Finns (n=155) took on average 9034 steps/day over one week as measured by the Yamax Digi Walker pedometer. The participants were mostly sedentary workers taking part in low to moderate physical activity less than twice a week [41].

Our findings should be viewed in the light of certain limitations. The moderately small sample size justifies only cautious generalization into MS populations with mild to moderate disability. Seasonality may have contributed to physical activity levels since our data for persons with MS was collected between February and August, whereas for the controls between August and January. However, both of the data collection periods partly covered winter time when physical activity is at the lowest [42]. We also observed a wide variation in the actibelt® parameters. Such marked variations in accelerometer data among MS subjects has been observed in earlier studies [22, 28, 36, 37]. We recognise the need to further establish the reliability, validity and feasibility of the actibelt® in persons with MS. The study was based on a preliminary version of the actibelt® concerning both hardware and parameter extraction algorithms. Hereupon, the array of algorithms has been re-tooled with the extraction of walking speed and distance [43]. The ecological validity of this algorithm has been demonstrated in healthy subjects [44], and the validity in a controlled environment in subjects with MS has been shown [45].

In conclusion, this study highlights how the levels of physical activity in persons with MS may vary depending on the measurement method used. Physical activity in ambulatory MS subjects may be well preserved as compared to relatively inactive healthy subjects. Future studies comparing activity levels between the healthy and MS subjects should strive to define more clearly whether the control groups consist of either sedentary or active persons. The seasonality effect on physical activity in MS deserves also future attention.

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