Original Contribution Kitasato Med J 2011; 41: 145-153

Daily physical activity in patients with schizophrenia

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Background: Although the amount of physical activity in daily life is an important issue to be taken into account in consideration of the prevention of the metabolic syndrome, obesity, diabetes, and ischemic heart disease in patients with schizophrenia, there are few research reports in the literature in which objective measurements have been taken and analysed.
Objective: The objective of the present study was to assess the amount of physical activity patients with schizophrenia had in their daily lives and to clarify various impacting factors.
Methods: The amount of daily physical activity in patients with schizophrenia (the schizophrenia group, n = 37) and in healthy volunteers (the control group, n = 41) was measured, using individual triaxial-accelerometers, and compared. Information regarding weight, body mass index, blood test, living conditions, and the PANSS (positive and negative syndrome scale) was also analysed.
Results: Comparing the schizophrenia group and the control group, revealed that total physical activity energy expenditure was significantly less and total activity duration was significantly shorter in the schizophrenia group. Remarkably, regression analysis on factors relevant to physical activity in the schizophrenia group revealed correlations to the number of household members and the negative symptoms of schizophrenia.
Conclusions: Consideration of these characteristics and tendencies is helpful to provide the best outpatient care possible for patients with schizophrenia and to take measurements to help treat them in light of their reduced levels of daily physical activity.

Key words: schizophrenia, physical activity, accelerometer, PANSS (positive and negative syndrome scale), metabolic syndrome

Abbreviations: BMI, body mass index; BMR, basal metabolic rate; 95% CI, 95% confidence interval; DLW, doubly labelled water; GEE, generalized estimating equation; HDL, high-density lipoprotein; LDL, low-density lipoprotein; NEAT, nonexercise activity thermogenesis; MET, metabolic equivalent; PAL, physical activity level; PANSS, positive and negative syndrome scale; PRC, partial regression coefficient; SD, standard deviation; TEE, total energy expenditure; WHO, World Health Organization

Background

The life expectancy of patients with schizophrenia is shorter than that of the general population.[1,2] Hennekens et al. reported that, in the United States, the average life expectancy of patients with schizophrenia was 61 years (57 years in men, 65 years in women) as opposed to that of the general population at 76 years (72 years in men, 80 years in women).[1] Coronary heart disease is a major factor in the reduced life expectancy of patients with schizophrenia. Hennekens et al. also reported that the prevalence of coronary heart disease in the general population is 33% while that in patients with schizophrenia is more than 75%.[1] It is therefore believed that the prevention of coronary heart disease, and of suicide (which is 10 to 20 times that than in the general population), is an important challenge in efforts to improve the reduced life expectancy of patients with

Received 20 December 2010, accepted 7 January 2011
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schizophrenia.[1-4] One of the reasons behind the high coronary heart disease mortality rate among patients with schizophrenia is the metabolic syndrome, for which the diagnosis criteria was issued by the WHO (World Health Organization) in 1999. It has been reported that the accumulation of risk factors for atherosclerosis-related diseases associated with insulin resistance and visceral fat accumulation, such as hypertension, dyslipidemia, and impaired glucose tolerance, takes place more often in patients with schizophrenia than in the general population.[5-8] Investigators have reported that the prevalence of the metabolic syndrome is an average of 3.7 times (range, 2.7~5 times) higher in patients with schizophrenia than that in the general population.[5-8]

The reasons for the high prevalence of the metabolic syndrome in patients with schizophrenia include (in addition to the possible side effects of antipsychotic medications used during treatment, such as weight gain, hyperlipidemia, impaired glucose tolerance, and decreased activity due to the sedative effects),[9-11] the fact that many patients end up staying inside the house all the time due to characteristic schizophrenia symptoms; and, as a result, the range of their physical activity most often becomes narrower and the amount of exercise reduced. Therefore, in order to prevent the metabolic syndrome and cardiovascular diseases in patients with schizophrenia, it is necessary to focus on the amount of exercise done by patients in their daily lives. However, this becomes problematic, in that, with regard to the amount of physical activity a patient gets in daily life, the reality is that, up to now, physicians and psychiatrists have had to guess or conjecture what that amount was merely from the interview with the patient along with assessing the patient's composure during the examination. Few investigators have reported methods to easily and accurately assess the actual amount of a patient's daily physical activity or on the measurement values of such.

Therefore, in the present study, we employed a small, lightweight, high-precision, monitoring device with a built-in triaxial accelerometer, developed in Japan in 2007, to take continuous physical-activity measurements without excessively burdening patients with schizophrenia. Using this device, it is possible to obtain detailed information about the amount of physical activity in a patient's daily life, a full picture of which cannot be obtained from the conventional questionnaire survey or measurement by a single axis accelerometer. For the present report, we conducted a study, using this physical-activity monitoring device, to identify the amount of physical activity in patients receiving outpatient treatment for schizophrenia as well as to identify related clinical characteristics.

Subjects and Methods

Subjects

The subjects were all Japanese patients who were receiving treatment on an outpatient basis, from December 2008 through September 2009, in the Department of Psychiatry in either the Kitasato University Hospital or the Kitasato University East Hospital, or in the Hatano Hospital Association Medical Corporation, who were found to satisfy the diagnostic criteria for schizophrenia (the International Classification of Diseases [ICD-10]) by at least two psychiatrists with at least 5 years of clinical experience, and who were determined, by their attending physicians, as having the capacity to consent to take part in the study (the schizophrenia group). Age- and gender-matched healthy volunteers (with no psychiatric disorder) were recruited through a poster campaign at Kitasato University, Kitasato University Hospital, and Kitasato University East Hospital (the control group).

This study was conducted upon approval by the Ethics Committee of Kitasato University School of Medicine. In addition, the purpose of the study was explained to the schizophrenia group and the control group both in writing and verbally, and only those giving their consent were allowed to participate in the study as subjects. In this study, personal information was managed in compliance with the Act on the Protection of Personal Information in Japan and measures were taken to ensure that personal information about the patients would not identify any names of the individuals.

Methods

Measurement of physical activity by triaxial accelerometer and record-keeping of daily activities: Physical activity monitoring devices (Actimarker EW4800; Panasonic Electric Works Co., Ltd., Osaka) were distributed to the subjects, along with instructions to have them attach it to the front of the right hip from when they get up until when they go to bed. They were also instructed to ensure that the device is properly attached for 14 days, and to act normally when the device is attached as they would in daily life. They were asked to fill in the record sheet to write down their activities during the period when the physical activity monitoring device was attached (e.g., whether or not the device was attached, the time when they had a meal, took a bath, slept, and exercised). All other activities during the day were recorded on an hourly basis. They were instructed that, on any day when they forgot to attach the device,

they should declare that fact on the activities record sheet for that day.

Physical activity monitoring device: The Actimarker EW4800 (Panasonic Electric Works Co., Ltd., Osaka) was used. This device has a built-in triaxial accelerometer and can measure the 3 axes of acceleration (x_i, up and down; y_i, left and right; z_i, forward and backward) with a measurement range of ± 19.6 m/s^2 (± 2 G) and resolution of 0.04 m/s^2, using a sampling frequency of 20 Hz. The accelerometer is 74.5 × 13.4 × 34.0 mm in size and 36 g in weight including batteries. When used, it is to be attached to the front of the right hip.

Method of calculating the intensity of activity: On the assumption that the total acceleration of a body corresponds to the intensity of activity, the intensity of activity was computed using the standard deviation (SD) of the 3-axis synthetic acceleration (3-axis average acceleration). As the intensity of activity was subsequently used to make an assumption on the metabolic equivalent of task (MET)[12] and energy expenditure, the average acceleration per minute was used. The value of acceleration per minute, i.e., Km, was computed as the SD of the 3-axis average acceleration, using formula (1).

Formula (1)

$$K_m = \sqrt{\frac{1}{n-1}\left[\left(\sum_{i=0}^{n} x_i^2 + \sum_{i=0}^{n} y_i^2 + \sum_{i=0}^{n} z_i^2\right) - \frac{1}{n}\left\{\left(\sum_{i=0}^{n} x_i\right)^2 + \left(\sum_{i=0}^{n} y_i\right)^2 + \left(\sum_{i=0}^{n} z_i\right)^2\right\}\right]}$$

x_i, y_i, z_i refer to the acceleration in each direction per minute and n refers to the number of samples per minute. As the sampling frequency of this device is 20 Hz, n will be 1,200 per minute. The operated value of acceleration per minute, i.e., Km, will be stored in the built-in memory with the time history.

Method of calculating the energy metabolism: The unit used to indicate the intensity of physical activity is expressed as MET.[12] This is a unit expressing the energy cost of physical activities as multiples of the resting metabolic rate, with resting being equivalent to 1 MET, normal walking to 3 METs, and brisk walking to 4 METs. The device computes MET values by applying simple linear regression to the value of acceleration per minute measured by accelerometer, i.e., Km. During the record keeping period, all data is stored in the built-in memory with the time history. Using the MET values obtained, the physical activity level (PAL) ([ACC] acceleration) per 24 hours is computed in accordance to the following formula (2).

Formula (2)

$$PAL_{ACC} = \frac{1}{n}\sum_{i=0}^{n} METs_i$$

n refers to the number of data per minute; and, therefore, per 24 hours, is 1440 (n = 1,440). The PAL values obtained and the basal metabolic rate (BMR) were combined to compute the total energy expenditure per 24 hours.[13] The BMR values were computed in reference to patient profiles and the statistics by the Ministry of Health, Labour and Welfare of Japan.[14] BMR was calculated using the equation of the Recommended Dietary Allowances for Japanese.[14]

Survey items concerning basic information: The following information was collected from both the schizophrenia group and the control group from the interview with the subject and in reference to the individual's medical record.

Physical information: gender, age, height (cm), weight (kg), body mass index (BMI), abdominal girth (cm), blood pressure (mmHg), pulse (strokes/minute).

Lifestyle information: educational attainment (less than a high-school education, high-school graduate, or completed higher education), years of education; family structure: number of household members, employment status (regular employment or student, working part-time, working at a small workshop for mentally disabled persons or attending the outpatient rehabilitation program, or not working); regular exercise (more than twice a week).

In addition, further information was collected from the schizophrenia group from the interview with the subject and in reference to the individual's medical records as follows. Information on mental illness: age of onset; disease duration (months); medication administered (whether or not antipsychotic medications were administered; overall quantity of antipsychotic medications converted into chlorpromazine[15,16]); duration of medication (months); existence of hypertension, diabetes, hyperlipidemia, and metabolic syndrome; and family history.

Positive and negative syndrome scale (PANSS) assessment: Psychiatrists trained to perform the PANSS rating[17] and who had prior experience with patients with schizophrenia for more than 5 years performed the PANSS assessment in the schizophrenia group at the start of the study.

Blood chemistry test: Prior to the start of the study, blood glucose, triglycerides, total cholesterol, HDL (high-density lipoprotein) cholesterol, LDL (low-density lipoprotein) cholesterol, and hemoglobin A1c were

Table 1. Demographic characteristics of the study participants

Variables	Schizophrenia group (n = 37)		Control group (n = 41)		P value
	Mean	SD	Mean	SD	
Age (years)	37.5	12.5	35.7	9.3	0.46
Gender (male) (%)	56.8 (n = 21)		53.7 (n = 22)		0.78
Education (%)	56.8 (n = 21)		0.0 (n = 0)		<0.001**
Number of people in the household	3.3	1.4	2.5	1.6	<0.05*
Habit of exercise (%)	62.2 (n = 23)		53.7 (n = 22)		0.45
Height (cm)	164.3	9.4	165.1	7.5	0.70
Weight (kg)	69.7	15.1	59.2	11.6	<0.001**
Waist circumference (cm)	88.5	14.8	76.0	8.3	<0.001**
BMI	25.9	5.5	21.6	3.1	<0.001**
Metabolic syndrome (%)	32.4 (n = 12)		2.4 (n = 1)		<0.001**
Age at onset	21.8	8.3			
Duration of illness (months)	187.6	118.6			
Duration of treatment with antipsychotics (months)	172.9	123.3			
Chlorpromazine equivalent doses (mg)	635.1	464.1			
PANSS					
Positive scale	13.8	4.2			
Negative scale	20.5	6.6			
General psychopathology scale	39.8	10.5			

*P < 0.05; **P < 0.001; SD, standard deviation; BMI, body mass index; PANSS, positive and negative syndrome scale; Education, percentage of those with less than a high-school education

Table 2. Measurements taken by a physical activity monitoring device for the schizophrenia and control groups

Variables	Schizophrenia group (n = 37)		Control group (n = 41)		P value
	Mean	SD	Mean	SD	
Basal metabolism (kcal/7 days)	10,041.3	1,387.3	9,428.6	1,403.1	0.06
TEE (kcal/7 days)	14,121.2	2,354.9	14,399.8	2,545.1	0.62
PAEE (kcal/7 days)	4,079.9	1,822.0	4,971.2	1,584.6	<0.05*
Steps (7 days)	53,429.6	31,764.7	64,616.0	20,637.6	0.07
Total activity time ≥1.1 METs (minutes/7 days)	2954.0	1080.8	3891.0	889.0	<0.001**
Total activity time = 1.1 METs~2.0 METs (minutes/7 days)	1,822.2	696.1	2,618.7	645.4	<0.001**
2.0 METs~3.0 METs	782.3	397.2	842.3	285.8	0.44
3.0 METs~4.0 METs	242.1	149.6	278.8	97.1	0.20
4.0 METs~5.0 METs	73.4	67.7	92.0	56.6	0.19
5.0 METs~6.0 METs	19.4	42.2	26.3	33.4	0.43
6.0 METs or more	14.6	41.0	32.9	73.3	0.18

TEE, total energy expenditure; PAEE, physical activity energy expenditure; MET, metabolic equivalent
Note: 1.0 MET is equal to the energy expended at the basal metabolic rate or at rest.[12]
*P < 0.05; **P < 0.001

measured.

Statistical analyses

In order to collate the data on the amount of activity, the sum of the values measured during a total of 7 days (i.e., the first 5 workdays and 2 days off when the subjects had the device attached to themselves, excluding the first and the last days of the assessment) was statistically analysed. P values of <0.05 were considered to indicate statistical significance.

Demographic characteristics of the study participants: In the comparison of the patients group and the control group, a Student *t*-test was performed to compare continuous variables and a chi-square test was used to compare categorical variables. In each test, a 5% significance level was specified in a two-sided test (Table 1).

Results of measurement by physical activity monitoring device for the schizophrenia group and the control group: The sum of the values measured during the applicable 7 days was used to collate the data on the amount of physical activity measured by the triaxial accelerometer and a Student's *t*-test was performed to make a comparison. A 5% significance level was specified in a two-sided test (Table 2).

Comparison of energy expenditure and total activity duration between the schizophrenia group and the control group: The results on physical activity energy expenditure (PAEE) (kcal/7 days) and total activity time of 1.1 METs or more (minutes/7 days) were compared between the patients group and the control group. A generalized estimating equation (GEE), adjusted for gender, educational attainment (less than a high-school education, a high-school graduate, or have completed higher education), BMI, age, and the number of household members, was used to compute estimated average values and these values were compared (Table 3).

Correlation between physical activity and clinical characteristics in the schizophrenia group: With regard to PAEE (kcal/7 days) and total activity time of 1.1 METs or more (minutes/7 days) in the schizophrenia group, the correlation between individual indices was assessed by

Table 3. Comparison of energy expenditure and total activity duration between the schizophrenia and control groups

Variables	Estimated mean value (95% CI)		Difference (95% CI)	P value
	Schizophrenia group	Control group		
PAEE (kcal/7 days)	3,880.1 (3,287.0~4,473.2)	5,235.2 (4,507.9~5,962.5)	1,355.1 (250.9~2,459.3)	<0.05*
Total activity time of 1.1 METs or more (minutes/7 days)	2,959.9 (2,620.7~3,299.0)	4,063.5 (3,651.5~4,475.5)	1,103.6 (564.5~1,642.7)	<0.001**

95% CI, 95% confidence interval; *P < 0.05; **P < 0.001

Table 4. Correlation between physical activity and clinical characteristics in the schizophrenia group

Variables	PAEE	Total activity time ≥1.1 METs
BMI	-0.19	-0.26
Age	-0.15	0.02
Age at onset	-0.19	-0.04
Duration of illness	-0.03	0.05
Education	-0.19	-0.17
Duration of treatment with antipsychotics	-0.03	0.08
Number of people in the household	0.38*	0.38*
Chlorpromazine equivalent doses	-0.16	-0.20
PANSS		
Positive scale	-0.15	-0.22
Negative scale	-0.33*	-0.27
General psychopathology scale	-0.26	-0.20

*P < 0.05

Table 5. Multiple regression analysis of physical activity in the schizophrenia group

	PAEE PRC (95% CI)	P value	Total activity time of 1.1 METs or more PRC (95% CI)	P value
Male	1,051.7 (-60.0~2,163.5)	0.64	-127.0 (-717.6~463.4)	0.67
BMI	-0.12 (-92~68.0)	0.77	-54.1 (-111.8~3.40)	0.07
Age	-21.8 (-104.3~60.6)	0.60	9.54 (-38.3~57.5)	0.70
Duration of illness	2.3 (-5.9~10.5)	0.58	0.53 (-4.3~5.4)	0.83
Education	712.5 (-326.5~1,751.5)	0.18	579.3 (-93.4~1252.0)	0.91
Number of people in the household	499.3 (146.3~852.6)	<0.05*	334.2 (124.0~544.4)	<0.05*
Chlorpromazine equivalent doses	-0.90 (-1.81~0.28)	0.06	-0.64 (-1.37~0.089)	0.09
PANSS				
Positive scale	-82.0 (-261.0~96.9)	0.37	-52.3 (-165.5~60.8)	0.37
Negative scale	-128.8 (-238.3~-19.3)	<0.05*	-30.4 (-96.3~35.5)	0.37
General psychopathology scale	49.1 (-43.2~141.4)	0.30	11.3 (-42.7~65.4)	0.68

*P < 0.05; PRC, partial regression coefficient

Pearson's correlation coefficient (Table 4).

Consideration of items relevant to physical activity (energy expenditure and total activity duration) in the schizophrenia group: With regard to items relevant to PAEE (kcal/7 days) and total activity time of 1.1 METs or more (minutes/7 days) in the schizophrenia group, in order to eliminate the effects of confounding variables, a GEE, adjusted for gender, educational attainment, age, disease duration, the number of household members, quantity of antipsychotic medications converted into chlorpromazine, PANSS ratings, and BMI, was used to perform a multiple regression analysis (Table 5).

Results

Clinical characteristics of the schizophrenia group and the control group (Table 1)

Measured values were obtained from 37 subjects in the schizophrenia group, 21 males and 16 females with a mean age of 37.5 years and from 41 subjects in the control group, 22 males and 19 females with a mean age of 35.7 years. Each item was compared between the two groups. There was no significant difference observed between the two groups in respect to age, gender, and height. However, the data on weight, abdominal girth, and BMI were significantly higher in the schizophrenia group ($P < 0.05$). The prevalence of the metabolic syndrome was 32.4% in the schizophrenia group and 2.4% in the control group ($P < 0.05$). Regarding educational attainment, the number of subjects who had less than a high-school education was significantly larger in the schizophrenia group, and the number of household members was significantly larger in the schizophrenia group ($P < 0.05$).

Results of measurements taken by the physical activity monitoring device for the schizophrenia and control groups (Table 2)

There were no significant differences in basal metabolism (kcal/7 days), total energy expenditure (kcal/7 days), or total steps taken. However, physical activity energy expenditure (kcal/7 days) was 4079.9 (kcal/7 days) in the schizophrenia group and 4,971.2 (kcal/7 days) in the control group--significantly less in the schizophrenia group. The total duration of activities assigned 1.1 METs or more (minutes/7 days) was 2,954.0 (minutes/7 days) in the schizophrenia group and 3,891.0 (minutes/7 days) in the control group--significantly shorter in the schizophrenia group. Regarding the breakdown of activity duration by activity intensity, the duration of activities assigned 1.1 METs or more but less than 2.0 METs was 1,822.2 (minutes/7 days) in the schizophrenia group and 2,618.7 (minutes/7 days) in the control group--significantly shorter in the schizophrenia group. However, there were no significant differences between the groups in the duration of activities assigned: 2.0 METs or more but less than 3.0 METs; 3.0 METs or more but less than 4.0 METs; 4.0 METs or more but less than 5.0 METs; 5.0 METs or more but less than 6.0 METs; and 6.0 METs or more.

Comparison between the measurements for the schizophrenia and control groups (Table 3)

Physical activity energy expenditure (kcal/7 days) was 3,880.1 (kcal/7 days) in the schizophrenia group and 5,235.2 (kcal/7 days) in the control group, and the effect size difference was 1,355.1--significantly less in the schizophrenia group. The total duration of activities

assigned 1.1 METs or more (minutes/7 days) was 2,959.9 (minutes/7 days) in the schizophrenia group and 4,063.5 (minutes/7 days) in the control group, and the effect size difference was 1,103.6--significantly less in the schizophrenia group.

Correlation between physical activity and physical and clinical characteristics in the schizophrenia group (Table 4)

Physical activity energy expenditure was positively correlated to the number of household members and negatively correlated to the PANSS negative scale. The total duration of activities assigned 1.1 METs or more was positively correlated to the number of household members.

Multiple regression analysis of physical activity in the schizophrenia group (Table 5)

With regard to physical activity energy expenditure, the number of household members (partial regression coefficient [PRC] 499.3; 95% confidence interval [95% CI] 146.3~852.6 and the PANSS negative scale (PRC -128.8; 95% CI -238.3~-19.3) were defined as being statistically significant. With regard to the total activity duration, the number of household members (PRC 334.2; 95% CI 124.0~544.4) was an item with a significant partial regression coefficient.

Discussion

We conducted the present study to identify the actual situation concerning physical activity in patients receiving outpatient treatment for schizophrenia in daily life. The results showed that: 1. physical activity energy expenditure was significantly lower in the schizophrenia group; 2. particularly, the total duration of activities assigned 1.1 METs or more was significantly shorter in the schizophrenia group; and 3. the results of a study on factors relevant to physical activity in the schizophrenia group demonstrated the involvement of the number of household members as a positive correlation factor and the severity of negative symptoms as a negative correlation factor. The main characteristic of this research is that a high-precision physical activity monitoring device with a built-in triaxial accelerometer was used to obtain accurate and objective measurement data. The methods previously employed to identify the amount of unsupervised activity were questionnaire surveys in which subjects would record their activities on the activities form and assessment based on the number of steps measured using a pedometer. However, with these methods, it was difficult to precisely and objectively identify the actual amount of physical activity and the actual activity intensity. Thereafter, a physical activity monitoring device with a built-in uniaxial (up-and-down movement) accelerometer was developed. However, with that device, it is difficult to measure movements other than walking, such as changing positions, sitting, and standing, as well as housework in daily life; and it significantly underestimates low-intensity exercise assigned 2.9 METs or less and, consequently, the total energy expenditure.[13] Furthermore, as a method of measuring energy metabolism, expired gas analysis and the doubly labelled water (DLW) method have also been employed, even though they are not completely performance friendly, due to the burden at the time of taking measurements, the necessary equipment, and cost. Regarding energy metabolism estimated by the triaxial accelerometer in the present study, a comparative study on DLW methods was carried out, and it was confirmed that the device can take measurements as precisely as the DLW method.[13,18]

A comparison of physical characteristics between the schizophrenia group and the control group revealed that the patients in the schizophrenia group tended to be obese, with a heavier body weight, an increased abdominal girth, and therefore a higher BMI. Many investigators have reported that patients with schizophrenia tend to be obese.[19,20] Fontaine et al. reported that in the United States, the proportion of those with BMI greater than or equal to 27 was 42% in patients with schizophrenia as opposed to 27% in the general population.[21] In the present study, many subjects in the schizophrenia group tended to be obese and suffered from the metabolic syndrome, thus confirming generally reported tendencies.[5-8] In the present study, to eliminate the effects of obesity in the schizophrenia group, regarding the amount of physical activity, and to assess the relationship between the existence of schizophrenia and the amount of physical activity, BMI was included as one of the confounding variables that were analysed and compared (Tables 3, 5).

The results of the present study demonstrated that physical activity energy expenditure was significantly less in the schizophrenia group and that the total duration of activities assigned 1.1 METs or more was also significantly shorter in the schizophrenia group. Previous reports on the amount of physical activity in patients with schizophrenia include: a report on the self-report study which demonstrated that levels were similar to those of the general population[19]; and another report on the results of a comparison using a self-report measure, the Yale Physical Activity Scale, which demonstrated

that the activity duration (hours/week) was significantly shorter and physical activity energy expenditure (kcal/week) was significantly less in the schizophrenia group.[22] That report also demonstrated, as a result of measurement by a single-axis accelerometer using a small number of samples (schizophrenia group, n = 16; control, n = 6), that the duration of light activity was shorter in the schizophrenia group and that there was no significant difference in moderate or vigorous activities.[22] The results of this study also identified tendencies similar to those noted in previous reports. Moreover, although the results of the present study showed that the total duration of activity assigned 1.1 METs or more was short among the schizophrenia group, because the minimum measurement, 1.1 METs, corresponds to the intensity of highly subtle activity, it is most likely that the sedentary period in daily life will be long. Compared with the general population, patients with schizophrenia significantly tend to be sedentary[23]; the accurate measurements taken in the present study also confirmed this tendency. Furthermore, Levine et al. referred to energy expenditure through less-than-3-METs low-intensity daily physical activity as nonexercise activity thermogenesis (NEAT) and suggested that a lack of NEAT could be one of the causes of obesity.[24] The results in the present study indicate that this tendency may be more apparent in the schizophrenia group. It may, therefore, be required to put more emphasis on lifestyle and exercise guidance working toward increasing the duration of low-intensity activity.

The results of the present study on factors relevant to physical activity in the schizophrenia group demonstrated the involvement of the number of household members as a positive correlation factor and the severity of negative symptoms as a negative correlation factor. Although, to our knowledge, it has never been pointed out in any previous reports, that the number of household members may be a significant lifestyle factor. These results are interesting in that they demonstrated that, the larger the number of household members, the larger the amount of their physical activity: the possibility is suggested that encouragement from family members and the division of housework within the family likely affects their activity. At the same time, it may be beneficial, when caring for patients who live alone, to be aware of a decrease in the amount of their activity, to send in visiting nurses to give them extra motivation and encouragement, and to recommend to them that they work at small workshops and attend exercise therapy programs. Negative symptoms are relevant to obesity and the metabolic syndrome[25] and positively related to a sedentary lifestyle.[26] A similar tendency was observed in the present study. The more severe a patient's negative symptoms, the more lifestyle guidance may be required in anticipation of a decrease in the amount of physical activity that patient has. On the other hand, in this study, the quantity of antipsychotic medications converted into chlorpromazine, and the duration of medical therapy, were not correlated to the amount of physical activity. Few researchers have reported on the direct relationship between antipsychotic medications and the amount of patients' physical activity; and although a broad generalization of the results in this study cannot be made, these collective results may be helpful in drug therapeutics. Further research is therefore warranted.

There were limitations in this study, and careful attention should be paid to these when interpreting the results. The subjects were patients receiving outpatient treatment who, having understood the study, agreed to cooperate. Therefore, a study of inpatients, who manifest severe symptoms, may have different results. Therefore, a broad generalization of the results of this study for all patients cannot be made. The number of patients who agreed to cooperate in this research was limited, therefore the sample size was small. The psychophysiological bias caused by the necessity of having to attach the device to one's own body daily cannot be ruled out. The quantity of antipsychotic medications being administered converted into chlorpromazine was examined, but the types of antipsychotic medications were not examined or introduced into the study. Thus, the difference of the effects of drug content on physical activity was not examined. And there was a statistical limitation. In a comparison of the amount of physical activity between the two groups and in the multiple regression analysis of the amount of physical activity in the schizophrenia group, to eliminate the effects of confounding variables that needed to be taken into consideration, a GEE was used. However, the likelihood of other confounding variables not included in this study cannot be ruled out.

The physical activity energy expenditure was significantly less and total activity duration was significantly shorter in the schizophrenia group compared with the control group. And the results of a regression analysis on factors relevant to the physical activity in the schizophrenia group revealed correlations to the number of household members as well as to negative symptoms. It is important to consider these characteristics and tendencies when providing outpatient care for patients with schizophrenia and to take accurate daily physical activity measurements that would prove helpful in providing treatment to patients with schizophrenia who have reduced their daily physical activity.

Acknowledgement

The authors thank Yutaka Yamanaka (Panasonic Electric Works Co., Ltd., Osaka) for technical advice on the triaxial accelometer.

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