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PAPER

Long-period accelerometer monitoring shows the role of physical activity in overweight and obesity

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CONTEXT: Physical activity (PA) plays an important role in obesity. A new accelerometer has been developed to assess total energy expenditure as well as PA.
OBJECTIVE: To investigate the association of PA with overweight and obesity in Japanese men and women, a large cross-sectional study was performed using a single-axis accelerometer.
DESIGN, SETTING AND PARTICIPANTS: Population-based cross-sectional study of Japanese 18–84 y of age. Height, body weight and PA were measured in 400 male and 388 female Japanese volunteers from 1999 to 2000. The outcome measurements were overweight and obesity, which are defined as a body mass index $\geq 25\,kg/m^2$. PA was measured for 1 to 4 weeks and was then categorized into three activity levels, which were defined as light, moderate and vigorous PA.
RESULTS: Prevalence of overweight and obesity was 22.3%. Number of steps and time spent in moderate and vigorous PA per day were lower in overweight and obese individuals. No difference was found in time spent in light PA. Individuals who are in the 4th and 5th quintile of moderate and vigorous PA showed a significantly lower body mass index. When odd ratios (ORs) of overweight and obesity estimated by logistic regression were used as effect measures, overweight and obesity were negatively associated with vigorous PA (ORs = 0.91).
CONCLUSION: These results indicate that overweight and obese individuals have a lower step rate and are spending less time for moderate to vigorous PA. Participation in vigorous PA is an important predictor of overweight and obesity.
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Keywords: accelerometer; overweight; Japanese and physical activity

Introduction

Obesity is one of the major concerns for public health according to recent increasing trends in obesity-related diseases such as Type 2 diabetes[1] and hyperlipidemia,[2] which are more prevalent in Japanese adults with body mass index (BMI) values $\geq 25\,kg/m^2$.[3] In the adult population of industrialized countries, it has been reported that obesity and higher body weight are strongly associated with a sedentary lifestyle and lack of physical activity (PA) at leisure time as well as at work.[4,5] A longitudinal epidemiological study has also revealed that regular PA prevents body mass gain and low PA is a risk factor for body mass gain and obesity.[6] Moreover, a participation in vigorous PA is related with a lower adiposity.[7,8] Therefore, the amount as well as the intensity of PA might be important potential determinants of overweight and obesity in Japanese population.

Several devices have been developed to assess the amount and intensity of PA in free-living conditions; the validation of these methods has been discussed.[9–12] Westerterp[13] has suggested that accelerometers are an objective tool for the assessment of PA in large populations over periods long enough to be representative of normal daily life. Since an increase in PA is an effective therapeutic intervention for the prevention and treatment of obesity and its related diseases, a single-axis accelerometer has been developed in Japan for assessing daily PA over long periods (6 weeks). The device has been used in a clinical setting to monitor daily PA and

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to prescribe appropriate levels of PA in order to reach their therapeutic goals. Although questionnaires have a disadvantage that subjects can easily overestimate or underestimate PA,[13] most population studies[4–6] have used a questionnaire to assess a daily PA because of its convenience. In some epidemiological studies, PA records were also used to estimate the amount and intensity of PA.[7,8] However, these procedures are very demanding for subjects. In contrast, the accelerometer is small, light, and easy to use. It also provides a digital data log that can be downloaded directly to a personal computer for further analysis. These properties make the accelerometer a useful tool to assess the amount and intensity of PA in a population study. Therefore, we have performed a cross-sectional study in a Japanese population using the accelerometer to investigate the relationship between amount and intensity of PA and prevalence of obesity.

Subjects and methods

Subjects

The subjects were 847 Japanese volunteers who underwent a regional medical examination in Fukuoka, Saga and Niigata regions of Japan and from university students in Fukuoka region. In all, 43 subjects (5.1%) refused to participate to the study and 16 accelerometer measurements (1.9%) had technical failures. Thus, 400 males and 388 females aged from 18 to 84 y were participated in this study from 1999 to 2000.

Measurements

Body mass index (BMI). For each participant, weight and height were directly measured and the BMI as the weight in kilograms divided by the squared height in meters (kg/m^2) was calculated. In USA, obesity is defined as BMI$>$30 kg/m^2, whereas 30$\geq$BMI$\geq$25 kg/m^2 is overweight. However, obesity for Japanese is defined as BMI$\geq$25 kg/m^2, according to the criteria established by the Japan Society for the Study of Obesity (JASSO).[14] Thus, we analyzed data using BMI$\geq$25 kg/m^2 and used terms 'overweight and obesity' for BMI$\geq$25 kg/m^2.

Physical activity. PA levels were measured by a single-axis accelerometer (Lifecorder, Suzuken Co. Ltd, Nagoya, Japan). The accelerometer ($625\times465\times260\,mm^3$, 40 g) was firmly attached to a belt or a waistband of the subject's clothing during all waking hours over 1 to 4 weeks period. The accelerometer is designed to detect acceleration along the vertical axis at the waist during body movements, and automatically calculate total energy expenditure (TEE) from the product of the step rate, acceleration and basal metabolic rate (BMR). The subject's data (age, gender, height and body weight (W)) are entered into the accelerometer for the estimation of BMR. The validity of this device for assessing PA correlates well with other methods of energy expenditure (EE) measurement such as doubly labeled water (DLW),[15] metabolic chamber[16] and indirect calorimeter.[16,17]

The device samples the acceleration at 32 Hz and assesses that ranging from 0.06 to 1.94 G (one G is equal to earth gravity acceleration). The acceleration signal is filtered by an analog bandpass filter and digitized. The device requires three criteria to detect the steps. The sampled acceleration was classified into four categories (The target threshold 1 and the target threshold 4 are corresponded to 0.06 and 1.94 G, respectively. The thresholds 2 and 3 were determined by the manufacturer.) A first criterion is that the peak magnitude of the acceleration was categorized to the target threshold 2 or higher. A second criterion is that the acceleration was kept continuously above 0.06 G for 0.19 to 1.56 s. A third criterion is that the interval of the acceleration wave is less than 1.56 s. When these three criteria were satisfied, the number of step was integrated. These second and third criteria have been established in order to cancel noise and/or artifacts.

The accuracy of the step counts detected by this device has been calibrated during the manufacturing process according to the Japanese Industrial Standards (JIS). Briefly, in the JIS, the error of step counts must be bellow $\pm$3% per artificial 1000 vibrations corresponding to 0.24 G (2.4 m/s^2) or 0.5 G (4.9 m/s^2). It must be noted that the accuracy of step counts in the accelerometer was confirmed at 0.24 G. Therefore, this accelerometer is considered as a superior assessment of ambulatory activity among older and/or low-fit individuals compared with the previously released pedometers, according to the higher sensitivity and the unique criteria. Furthermore, the reported error of the step counts of this devise was within $\pm$1% during treadmill walking.

By measuring the magnitude and frequency of accelerations, the device determines the level of movement intensity every 4 s. If the device detects three or more step counts during a 4-s period, a value of 1–9, based on the intensity of the PA (1 = minimal intensity of PA, 9 = maximal intensity of PA) is given for that time period. In contrast, if the device detects two or less steps during a 4-s period, a zero value is given to that time period, indicating there was no movement. The PA is subsequently converted to energy expenditure (EE_{PA}):

$$\mathrm{EE_{PA}(kcal)} = Ka\times W(kg)$$

where '*Ka*' is a constant with nine values experimentally determined by the manufacturer to reflect acceleration under various conditions and is considered to be confidential by the manufacturer.

If an acceleration pulse due to PA is not immediately succeeded by another acceleration pulse, then it is not counted as zero. However, a level of 0.5 is arbitrarily ascribed for 3 min. It is assumed that the subject is standing up and maintaining that state (or sitting down). The latter posture involves a higher EE than resting supine position. These minor activities will show isolated spurts of acceleration, since walking and moving around are typically rhythmic activities. EE due to minor activities ($EE_{minorAct}$, that is, posture changes, light desk work, etc) is calculated by using BMR and a constant *Kx*:

$$EE_{\mathrm{minorAct}}(\mathrm{kcal}) = Kx\times \mathrm{BMR\,(kcal/\,min)}$$

The value of the constant '*Kx*' is not given here, since it is considered to be confidential by the manufacturer.

TEE is calculated with the following equation:

$$\mathrm{TEE} = \frac{1}{10}\mathrm{TEE} + \mathrm{EE_{PA}} + \mathrm{EE_{minorAct}} + \mathrm{BMR}$$

where $\frac{1}{10}$ TEE (kcal) is dietary-induced thermogenesis.

$$\mathrm{BMR\,(kcal)} = Kb \times \mathrm{BSA} \times T \times 1/10000$$

'*Kb*' is a standard value of Japanese (kcal/m^2/h),[18] BSA is body surface area (cm^2) and 'T' is time (h)

$$\mathrm{BSA\,(cm^2)} = W^{0.444}(\mathrm{kg}) \times \mathrm{HT}^{0.663}(\mathrm{cm}) \times 88.83$$

Data analysis and statistics

No correction factor was used to correct for some activities (swimming, weight lifting bicycling, etc), which can not be captured by accelerometers; therefore, TEE might be under-estimated.[19,20] Since epidemiological studies investigating the effects of PA on public health are often interested in categorizing various activities into metabolic equivalent (MET) intensities,[21] PA was also categorized into three activity categories, which are defined as light PA (PA levels 1–3), moderate PA (PA levels 4–6) and vigorous PA (PA levels 7–9) by using an equation ($\mathrm{METs} = 0.043x^2 + 0.379x + 1.361$, where x represents the PA level, $r = 0.929$).[16]

Student's *t*-test was used to determine the distinctive effects of gender and BMI. We also used the one-way ANOVA to determine the effect of age and time spent in each PA level. When the ANOVA revealed a significant effect, Tukey–Kramer *post hoc* test was applied to identify which conditions were different from each other. Since there was a significant age effect on BMI, the ANCOVA was performed to evaluate the effect of time spent in each PA level on BMI with age as a covariance. Values are expressed as mean ± s.e.m.

In order to explore the association between obesity and PA, odd ratios (ORs) were calculated by logistic regression analysis. Thus, ORs were interpreted as relative risks. Indicator (factored) variables for each category of independent variable were created by dividing into five similar-sized quintiles except for age, sex and vigorous PA. The lowest category was used as the reference category. ORs with 95% confidence intervals (95% CI) were estimated for each variable. OR of each variable was adjusted for the other variables, that is, $\mathrm{OR_{Ad}}$ of age is adjusted for gender and intensities of PA. Tests for trend were performed after unfactorizing and adding it to the previous model. The likelihood ratio statistic was used to evaluate the significance of linear trends. All the statistical analyses were carried out using StatView (SAS Institute, Cary, NC, USA). All the statistical significance was considered at $P < 0.05$.

Results

The overall prevalence of overweight and obesity in this population were 22.3% and that of obesity was 2.3%. Prevalence of overweight and obesity, and BMI in age categories and distinction of gender and PA are presented in Table 1. Prevalence of overweight and obesity was 8.2, 23.3, 29.6 and 23.3% for age quartiles of 18–29, 30–49, 50–69 and 70–84 y, respectively. BMI in the age group of 50–69 y was significantly higher than in groups of 18–29 and 70–84 y, whereas no difference was found between 50–69 and 30–49 y groups. According to gender, prevalence of overweight and obesity was 22.8% for men and 21.9% for women. Individuals who are in the 4th and 5th quintiles of moderate PA showed a significantly lower BMI than those in the 1st and 3rd quintile of moderate PA. Individuals who are in the 4th and 5th quintiles of vigorous PA also showed a significantly lower BMI than those in other categories. Regarding the effects of PA on BMI, the ANCOVA with adjustment for age revealed the same significant results as the ANOVA without adjustment for age.

Number of steps in the age quartiles of 18–29, 30–49, 50–69 and 70–84 y was 8910 ± 221, 9128 ± 269, 7922 ± 217 and 5512 ± 168 (mean ± s.e.m.), respectively. Subjects in the age group of 50–69 y showed significantly lower steps than those in the younger quartiles, whereas 70–84 y subjects showed the lowest value. On the other hand, there was no difference in gender (males: 7481 ± 171 and females 7587 ± 166).

Table 2 presents TEE as well as the number of steps and time spent in PA in distinction of BMI. Overweight and obese individuals showed higher TEE and BMR, whereas number of steps and time spent in moderate and vigorous PA were lower than nonobese individuals. No difference was found in $\mathrm{EE_{PA}}$ and time spent in light PA.

Prevalence of obesity according to age, gender and intensities of PA was estimated by logistic regression (Table 3). After adjustment for gender and intensities of PA, age was not independently related to prevalence of obesity. Moreover, after adjustment for age and PA, gender was not independently related to prevalence of obesity. However, time spent in vigorous PA was significantly negatively related with prevalence of obesity when adjusted for age, gender and light and moderate PA.

Discussion

The purpose of the present study was to investigate the role of PA in obesity by using a single-axis accelerometer in adult Japanese population. Our data revealed that overweight and obese individuals had a lower step rate and spent less time for moderate to vigorous PA. Moreover, overweight and obesity was inversely related with time spent in vigorous PA.

Prevalence of obesity in Japanese population estimated by international criteria (BMI $\geq 30\,\mathrm{kg/m^2}$)[22,23] is quite low (2 or 3%)[24] compared to the data in Western populations (from 7 to 20%).[25–27] The overall prevalence of obesity in our data set was 2.3%, which is consistent with previous Japanese data, which includes 23 556 males and 28 751 females aged 15–84 y.[24] Prevalence of overweight and obesity in our study was 22.3%, which is also consistent with the previous study.[24] Thus, our subjects well represent Japanese population for a study of obesity.

Table 1 Estimated prevalence of overweight and obesity in Fukuoka, Saga and Niigata regions of Japan

		BMI≥25 kg/m²		BMI≥30 kg/m²				
	No. of subjects	No.	%	No.	%	BMI	Height	Weight
Age (y)								
18–29	146	12	8.2	2	1.4	21.4±0.23[a]	165.0±0.69[a]	57.8±0.89[a]
30–49	150	35	23.3	2	1.3	23.2±0.23[b,c]	163.5±0.70[a]	62.3±0.85[b]
50–69	230	68	29.6	10	4.3	23.6±0.21[b]	158.3±0.52[b]	59.3±0.64[a]
70–84	262	61	23.3	4	1.5	22.9±0.19[c]	156.1±0.52[c]	55.8±0.55[c]
Gender								
Males	400	91	22.8	9	2.3	23.0±0.15	164.9±0.40[a]	62.8±0.50[a]
Females	388	85	21.9	9	2.3	22.8±0.16	154.5±0.33[b]	54.3±0.41[b]
Light PA (min/day)								
4.3–38.1	158	44	27.8	6	3.8	23.3±0.26	157.8±0.68[a]	58.1±0.81
38.2–48.1	158	32	20.3	1	0.6	22.7±0.23	159.6±0.74[a,b]	57.9±0.72
48.2–58.8	157	36	22.9	2	1.3	22.8±0.24	160.9±0.78[b]	59.1±0.82
58.9–73.8	157	38	24.2	6	3.8	22.9±0.28	160.1±0.67[a,b]	58.9±0.86
73.9–162.3	158	26	16.5	3	1.9	22.8±0.23	160.6±0.69[a,b]	59.0±0.78
Moderate PA (min/day)								
0.0–6.7	158	48	30.4	1	0.6	23.3±0.24[a]	156.6±0.64[a]	57.3±0.73[a]
6.8–13.6	158	36	22.8	5	3.2	23.1±0.24[a,b]	158.7±0.74[a,b]	58.3±0.79[a,b]
13.7–21.9	157	43	27.4	7	4.5	23.3±0.27[a]	160.9±0.73[b]	60.6±0.89[b]
22.0–32.0	157	28	17.8	4	2.5	22.3±0.25[b]	161.1±0.66[b]	58.0±0.77[a,b]
32.1–101.4	158	21	13.3	1	0.6	22.4±0.22[b]	161.8±0.72[c]	58.8±0.79[a,b]
Vigorous PA (min/day)								
0.0	214	58	27.1	3	1.4	23.2±0.20[a]	157.3±0.58[a]	57.5±0.64[a]
0.1–0.9	236	62	26.3	6	2.5	23.2±0.31[a]	158.8±0.54[a,b]	58.5±0.61 [a,b]
1.0–1.9	107	26	24.3	7	6.5	23.2±0.27[a]	161.3±0.82[b]	61.2±0.99[b]
2.0–4.9	142	22	15.5	2	1.4	23.0±0.25[b]	162.7±0.77[c]	59.1±0.95[a,b]
5.0–34.7	89	8	9.0	0	0.0	21.8±0.22[b]	162.0±1.04[c]	57.3±1.11[a,b]

BMI = body mass index. BMI values are expressed as mean±s.e.m. Different alphabet letters show significant differences analyzed by the ANOVA and Tukey–Kramer *post hoc* test ($P<0.05$).

Table 2 EE step and time spent for PA measured by the Lifecorder according to BMI

	BMI	
	<25 kg/m²	≥25 kg/m²
Number of subjects	612	176
Height (cm)	160.1±0.36	158.9±0.66
Weight (kg)	55.6±0.34	68.9±0.63*
TEE (kcal/day)	1762±12	1857±24*
BMR (kcal/day)	1228±7.5	1302±15.8*
EE due to PA (kcal/day)	193±4.3	194±8.5
No. of steps (counts/day)	7756±137	6766±233*
Time spent in PA (min/day)		
Light PA	57.2±0.96	53.5±1.79
Moderate PA	21.4±0.63	17.1±1.13*
Vigorous PA	2.37±0.17	1.11±0.15*

Values are expressed as mean±s.e.m. *Significant differences analyzed by the Student's *t*-test ($P<0.05$).

Several correlation studies on motion sensors and DLW have been published.[9–11] A tri-axial accelerometer for movement registration showed a close correlation with the DLW assessed PA level,[9,10] whereas no correlation was reported between a single-axis accelerometer, the Caltrac and DLW.[11] However, Ekelund *et al*[28] have reported that another single-axis accelerometer, the Computer Science and Application's activity monitor, showed a significant correlation with the DLW measurement. They have suggested that the discrepancy between studies may be due to different activity monitors used since they may differ in their sensitivity in measuring vertical acceleration during free-living condition.[28] In our recent study, TEE assessed by the accelerometer showed a significant correlation with TEE measured by the DLW during 2 weeks free-living condition in Japanese men ($r=0.83$, $P<0.0001$).[15] Moreover, TEE assessed by the accelerometer showed a significant correlation with TEE measured by a metabolic chamber ($r=0.928$, $P<0.001$).[16] Furthermore, PA levels of accelerometer were significantly correlated with EE ($r=0.808$, $P<0.001$).[16] In addition, Schneider *et al*[29] have compared 13 models of pedometer in a free-living condition, and have suggested that this accelerometer and three others are suitable for applied PA research. Since the device is a small and light accelerometer that can memorize data every 2 min for 6 weeks and directly transfer the data to an Excel file, it is a useful tool to assess the TEE, PA levels and step rate in a population study.

Table 3 OR_{Ad} of overweight and obesity (BMI ≥ 25 kg/m^2) according to age, gender or time spent in different intensities of PA

	No. of subjects	*OR_{Ad}*[a]	*95% CI*	$\chi^2_{trend\ test}$[b]
Age (y)				
18–29	146	1.00		
30–49	150	3.39	1.60–7.17	
50–69	230	3.96	1.87–8.40	
70–84	263	2.32	1.06–5.07	
OR across category[c]		1.009	0.998–1.021	$P = 0.12$
Gender				
Males	400	1.00		
Females	389	1.00	0.70–1.42	
OR across category		0.989	0.703–1.394	$P = 0.95$
Light PA (min/day)				
4.3–38.1	158	1.00		
38.2–48.1	158	0.76	0.44–1.31	
48.2–58.8	157	0.89	0.51–1.55	
58.9–73.8	157	0.92	0.52–1.62	
73.9–162.3	158	0.53	0.29–1.00	
OR across category		0.998	0.990–1.006	$P = 0.65$
Moderate PA (min/day)				
0.0–6.7	158	1.00		
6.8–13.6	158	0.67	0.38–1.17	
13.7–21.9	157	1.05	0.59–1.85	
22.0–32.0	157	0.63	0.33–1.22	
32.1–101.4	158	0.51	0.25–1.05	
OR across category		0.994	0.980–1.208	$P = 0.38$
Vigorous PA (min/day)				
0.0	214	1.00		
0.1–0.9	236	1.07	0.66–1.73	
1.0–1.9	107	1.24	0.65–2.36	
2.0–4.9	142	0.94	0.45–1.96	
5.0–34.7	89	0.56	0.22–1.46	
OR across category		0.910	0.834–0.922	$P = 0.03$

[a]OR_{Ad} of each variable is adjusted for the other variables, that is, OR_{Ad} of age is adjusted for gender and intensities of PA. [b]χ^2 trend test: chi-squared test for trend with one degree of freedom. [c]OR across categoty was estimated after adding the unfactored variable to the previous model.

In the adult population of the United States, overweight (BMI 25–29.9 kg/m^2) or obese (BMI ≥30 kg/m^2) individuals have reported less regular PA compared to individuals with BMI of less than 25 kg/m^2.[30] In the adult population of the European Union, obesity and higher body weight are strongly associated with a sedentary lifestyle (amount of time sitting down) and lack of PA.[4] Moreover, the evidence reviewed by Jebb and Moore[31] clearly showed that low levels of activity are associated with overweight and obesity. In the present study, number of steps and time spent in moderate and vigorous PA were lower in overweight and obese individuals than in normal-weight individuals. These results indicate that overweight and obese people are moving less and that they participate less in moderate to vigorous PA. The Centers for Disease Control and Prevention in the United States and the American College of Sports Medicine have recommended that every adult should perform 30 min or more of moderate-intensity PA on most, preferably all, days of the week.[21] In the present study, individuals who are participating in moderate PA more than 30 min/day showed a significantly lower BMI than the others (22.4 ± 0.2, 184 and 23.0 ± 0.1, 604, respectively; mean ± s.e.m., *n*), supporting the recommendation from the Centers for Disease Control and Prevention in the United States and the American College of Sports Medicine.[21] Moreover, individuals who are in the 4th and 5th quintile of moderate PA and 5th quintile of vigorous PA showed a lower BMI than the others. These results also support the notion that individuals who engage in vigorous PA are leaner than individuals who never take part in such activities.[8] On the other hand, the current study shows that energy expenditure due to PA and TEE in overweight and obese are, respectively, similar and higher than normal weight. The obese individuals are often less active, but since they carry a heavier load requiring more energy, their TEE may not be lower.

When OR estimated by logistic regression was adjusted by age, gender and time spent in PA (light, moderate and vigorous PA), and was used as effect measures, overweight and obesity were associated with time spent in vigorous PA (inversely). OR across category of time spent in vigorous PA was 0.91. Thus, this result indicates that time spent in vigorous PA is significantly associated with overweight and obesity. Furthermore, subjects spent 3.93, 1.42 and 0.15% of day for light, moderate and vigorous PA, respectively. Taken together, it suggests that even for a very small part of a day, participation in vigorous PA is important for the prevention of overweight and obesity.

A few epidemiological studies have investigated the step rate and obesity levels. Recently, preliminary pedometer indices for public health have been reported to classify PA levels in healthy adults:[32] (i) <5000 steps/day may be used as a ‘sedentary lifestyle index’, (ii) 5000–7499 steps/day is typical of daily activity excluding sport/exercise and might be considered as ‘low active’, (iii) 7500–9999 steps/day likely includes some volitional activities (and/or elevated occupational activity demands) and might be considered as ‘somewhat active’, and (iv) ≥10 000 steps/day indicates the level that should be used to classify individuals as ‘active’. When we compared BMI according to this classification by using the one-way ANOVA and also ANCOVA (adjusted by age) as well as the Tukey–Kramer *post hoc* test, ‘somewhat active’ individuals showed significantly lower BMI than those in ‘sedentary’ and ‘low active’ classifications ($P < 0.05$). Moreover, step rate in overweight and obese individuals was lower than normal-weight individuals and there was a significant correlation between BMI and step rate ($r = -0.093$; $P = 0.009$). Lower BMI in individuals whose step rates are <6000,[33] lower step rate in obese[34] and the negative correlation[33–36] were also reported in North American. Furthermore, longitudinal studies demonstrate that increasing step rate could improve body mass, blood pressure, serum lipid profiles, as well as insulin sensitivity and resistance in individuals who have history of obesity-related diseases.[37–41] These observations indicate the necessity and usefulness of step counter in the prevention and treatment of obesity and related diseases.

In conclusion, this is the first epidemiological study to demonstrate the importance of moderate to vigorous PA and step rate in the level of obesity in Japanese population. Our results support the PA recommendation from the Centers for Disease Control and Prevention in the United States and the American College of Sports Medicine[21] as well as our earlier finding in Caucasians.[8] From a clinical standpoint, vigorous PA should not be prescribed to individuals who are at risk for sudden death or to overweight and obese individuals who are not used to exercise. Under these circumstances, the most prudent approach remains a moderate PA with a progressive increase in duration, frequency and intensity. With the increasing prevalence of obesity in industrialized countries, wide use of an accelerometer that can assess PA levels and step rate for a long-enough period may provide better monitoring and managing lifestyle, which may contribute to the prevention and treatment of lifestyle-related diseases.

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