




# Physical activity and prevalence of erectile dysfunction in Japanese patients with type 2 diabetes mellitus: The Dogo Study

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## Keywords

Exercise, Physical activity, Sexual function

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## ABSTRACT

**Aims/Introduction:** To date, there is no evidence regarding the association between physical activity (PA) and erectile dysfunction (ED) among Japanese patients with type 2 diabetes mellitus. We investigated this issue among Japanese patients with type 2 diabetes mellitus.

**Materials and Methods:** Study participants were 460 male Japanese patients with type 2 diabetes mellitus. The definitions of exercise habit, walking habit and fast walking were based on a self-administered questionnaire regarding PA behavior. Participants were classified into one of four PA levels based on the number of 'Yes' answers to the three questions in the questionnaire: (i) lowest; (ii) lower; (iii) moderate; and (iv) higher. Severe ED and moderate-to-severe ED were based on Sexual Health Inventory for Men score <8 and <12, respectively.

**Results:** The prevalence of moderate-to-severe ED, severe ED, exercise habit, walking habit, and fast walking was 64.6, 51.1, 36.3, 41.3 and 37.6%, respectively. Walking habit was independently inversely associated with moderate-to-severe ED and severe ED. Exercise habit was independently inversely associated with severe ED, but not moderate-to-severe ED. Higher PA was independently inversely associated with moderate-to-severe ED and severe ED (adjusted odds ratio 0.42, 95% confidence interval 0.21–0.85; and adjusted odds ratio 0.38, 95% CI: 0.19–0.73, respectively). There was a statistically significant inverse exposure–response relationship between the PA level and moderate-to-severe ED and severe ED (*P* for trend = 0.02 and 0.005), respectively.

**Conclusions:** PA might be inversely associated with ED in Japanese patients with type 2 diabetes mellitus.

## INTRODUCTION

Erectile dysfunction (ED) is a distressing complication that affects quality of life. In a meta-analysis of population-based studies, physical activity (PA) was inversely associated with ED<sup>1</sup>. Similarly, the inverse association between PA and ED was observed among patients with diabetes in Western countries<sup>2–4</sup>.

Two studies of Asian patients with type 2 diabetes mellitus had reported the inverse association between PA and ED<sup>5,6</sup>.

The prevalence of ED based on a validated questionnaire among Japanese patients with type 2 diabetes mellitus is high<sup>7–9</sup>. However, in routine clinical practice in Japan, insufficient attention has been paid to ED. Furthermore, no study has examined this issue among Japanese patients. The purpose of the present study was to investigate the association between PA and ED

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among Japanese diabetes patients. Herein, we examined the association between nocturia, diabetic neuropathy, alcohol consumption, and self-reported sitting time and ED among Japanese patients with type 2 diabetes mellitus using baseline data from The Dogo Study carried out in Japan<sup>9–12</sup>.

## METHODS

### Study population

The Dogo Study is an ongoing multicenter prospective cohort study of patients with diabetes<sup>9–14</sup>. All 1,051 Japanese patients with type 2 diabetes mellitus gave informed consent and were enrolled from the participating local base hospitals in Ehime prefecture. The final analysis sample in the present study consisted of 460 patients, with 591 patients excluded because of female sex and/or incomplete data. The present study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki (6th revision, 2008) as reflected in *a priori* approval by the institutional review board of Ehime University Graduate School of Medicine.

### Participants' characteristics

We used a self-administered paper-and-pencil questionnaire, medical records and admission data to collect the variables. The definitions of each of the variables were described previously<sup>9–17</sup>. The history of depression was assessed based on the self-administered questionnaire. The definition of microvascular complications was based on the Fukuda standard<sup>18</sup>, Classification of Diabetic Nephropathy 2014<sup>19,20</sup> and abbreviated diagnosis of diabetic neuropathy<sup>21</sup>, respectively.

### Assessment of PA

The validation study of a brief questionnaire regarding PA had been carried out in Japan<sup>22</sup>. We used the same questionnaire to collect information on the following three PA behaviors. The definition of exercise habit: they are in the habit of doing exercise where they sweat lightly for over 30 min each, twice weekly, for over a year. The definition of walking habit: they walked or participated in an equivalent PA for at least 1 h per day. The definition of fast walking: their walking speed was faster than the speed of others their own age and sex.

Participants were also divided into four PA levels (lowest, lower, moderate and higher) according to the abovementioned PA behavior as follows: (i) lowest PA level: negative responses to all the other three; (ii) lower PA level: positive response to one of three; (iii) moderate PA level: positive responses to two of three; and (iv) higher PA level: positive responses to all three.

### Assessment of ED

The severity of ED was assessed using the validated Japanese five-item version Sexual Health Inventory for Men (SHIM)<sup>23</sup>. The SHIM score is used widely for screening ED in the clinical practice setting. In the present study, the definition of

moderate-to-severe ED was a score of <12 points and severe ED was a score of <8 points.

### Statistical analysis

We selected age, body mass index, waist, duration of type 2 diabetes, current smoking, current drinking, hypertension, dyslipidemia, coronary artery disease, stroke, glycosylated hemoglobin, nocturia, depression, diabetic neuropathy, diabetic retinopathy and diabetic nephropathy as potential confounding factors. Age, body mass index, waist, duration of type 2 diabetes and glycosylated hemoglobin were used as continuous variables. Logistic regression analysis was carried out to estimate the adjusted odds ratios (ORs) and the 95% confidence intervals (CIs). Multiple regression logistic analyses were used to adjust for potential confounding factors. The trend of an association was assessed using a logistic regression model assigning consecutive integers to the PA level categories. All analyses were carried out using the Sas software package version 9.4 (SAS Institute, Inc., Cary, North Carolina, USA).

## RESULTS

The characteristics of the 460 patients are listed in Table 1. Of the 460 patients with type 2 diabetes mellitus, mean age, glycosylated hemoglobin, and duration of type 2 diabetes mellitus were 60.8 years, 8.0% and 11.0 years, respectively. The SHIM score was 8.8, and the prevalence values of moderate-to-severe ED and severe ED were 64.6 and 51.1%, respectively. The prevalence values of exercise habit, walking habit, and fast walking were 36.3, 41.3 and 37.6%, respectively. The percentage of lowest, lower, moderate, and higher PA were 36.3, 27.4, 21.1 and 15.2%, respectively.

The relationships between ED and PA habit are shown in Table 2. The inverse association between fast walking and ED was observed in the crude analysis. After adjustment for confounding factors, however, the inverse association between fast walking and ED had disappeared. In contrast, after adjustment for confounding factors, walking habit was independently inversely associated with ED, (adjusted ORs 0.62, 95% CI: 0.39–0.979 and 0.63, 95% CI: 0.41–0.98, respectively). Exercise habit was independently inversely associated with severe ED, but not moderate-to-severe ED (adjusted OR 0.52, 95% CI: 0.32–0.82).

Only a higher PA level was independently inversely associated with moderate-to-severe ED and severe ED, respectively (Table 3; adjusted ORs 0.42, 95% CI: 0.21–0.85 and 0.38, 95% CI: 0.19–0.73, respectively). However, regardless of severity of ED, an inverse association between PA level and moderate-to-severe ED and severe ED was found, respectively ( $P$  for trend = 0.02 and  $P$  for trend = 0.005).

## DISCUSSION

The present study showed that exercise habit was independently inversely associated with severe ED, and walking habit and PA level were independently inversely associated with moderate-to-severe ED and severe ED, respectively. To our

**Table 1** | Clinical characteristics of the 460 study participants

Variable	n (%)
Mean age (years)	60.8 ± 11.6
Mean BMI (kg/m <sup>2</sup> )	24.9 ± 4.5
Mean waist (cm)	87.3 ± 18.3
Mean HbA1c (%)	8.0 ± 1.9
Mean duration of type 2 diabetes mellitus (years)	11.0 ± 9.8
Use of antihyperglycemic agent (%)	291 (63.3)
Use of insulin (%)	118 (25.7)
Current drinking (%)	249 (54.1)
Current smoking (%)	122 (26.5)
Hypertension (%)	305 (66.3)
Dyslipidemia (%)	331 (72.0)
Diabetic neuropathy (%)	275 (59.8)
Diabetic retinopathy (%)	122 (26.5)
Diabetic nephropathy (%)	49 (10.7)
Stroke (%)	32 (7.0)
Coronary artery disease (%)	47 (10.2)
Nocturia (%)	383 (83.3)
Depression (%)	23 (5.0)
Mean SHIM score	8.8 ± 6.8
Moderate-to-severe ED, SHIM <12 (%)	297 (64.6)
Severe ED, SHIM <8 (%)	235 (51.1)
Physical activity behavior	
Exercise habit, yes/no (%)	167 (36.3)
Walking habit, yes/no (%)	190 (41.3)
Fast walking, yes/no (%)	173 (37.6)
Physical activity level	
Lowest (%)	167 (36.3)
Lower (%)	126 (27.4)
Moderate (%)	97 (21.1)
Higher (%)	70 (15.2)

BMI, body mass index; ED, erectile dysfunction; Hb1Ac, glycated hemoglobin; SD, standard deviation; SHIM, Sexual Health Inventory for Men.

knowledge, this is the first study to show the inverse association between PA and ED among Japanese patients with type 2 diabetes mellitus.

In the general population, evidence exists regarding the association between PA and ED<sup>1</sup>. Several pieces of evidence exist regarding the association between PA and ED among patients with type 2 diabetes mellitus. PA (metabolic equivalents [METs]) was significantly inversely associated with ED in an Italian study of 555 men with type 2 diabetes mellitus aged 35–70 years<sup>2</sup>. Similarly, in an Israeli study of 1,040 patients with diabetes aged 18 years or older, PA at work and during leisure time was significantly inversely associated with ED based on The International Index of Erectile Function (IIEF)<sup>3</sup>. In a USA study of 373 men with type 2 diabetes mellitus, maximum METs (cardiorespiratory fitness) measured using standard exercise testing was significantly inversely associated with ED based on IIEF<sup>4</sup>.

In an Asian general population, the association between PA and ED was still unclear. In a Korean study of 3,501 men, only job-related activity was significantly inversely associated with

**Table 2** | Crude and adjusted odds ratios and 95% confidence intervals for erectile dysfunction in relation to physical activity behavior

Variable	Prevalence (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Moderate-to-severe ED (SHIM <12)			
Exercise habit			
No	185/293 (63.1)	1.00	1.00
Yes	112/167 (67.1)	1.19 (0.80–1.78)	0.74 (0.44–1.22)
Walking habit			
No	178/270 (65.9)	1.00	1.00
Yes	119/190 (62.6)	0.87 (0.59–1.28)	0.62 (0.39–0.979)
Fast walking			
No	199/287 (69.3)	1.00	1.00
Yes	98/173 (56.7)	0.58 (0.39–0.86)	0.64 (0.40–1.01)
Severe ED (SHIM <8)			
Exercise habit			
No	151/293 (51.5)	1.00	1.00
Yes	84/167 (50.3)	0.95 (0.65–1.39)	0.52 (0.32–0.82)
Walking habit			
No	141/270 (52.2)	1.00	1.00
Yes	94/190 (49.5)	0.90 (0.62–1.30)	0.63 (0.41–0.98)
Fast walking			
No	158/287 (55.1)	1.00	1.00
Yes	77/173 (44.5)	0.66 (0.45–0.96)	0.73 (0.47–1.13)

Odds ratios were adjusted for age, body mass index, waist, duration of type 2 diabetes, current smoking, current drinking, hypertension, dyslipidemia, coronary artery disease, stroke, glycated hemoglobin, nocturia, depression, diabetic neuropathy, diabetic retinopathy, and diabetic nephropathy. CI, confidence interval; ED, erectile dysfunction; OR, odds ratio; SHIM, Sexual Health Inventory for Men.

ED: regular exercise activity was not associated with ED<sup>24</sup>. In a Singapore study of 729 men aged 30 years and older, PA was not associated with ED<sup>25</sup>. In a Chinese study of 4,303 males aged 17–80 years, PA was inversely associated with ED only in current smokers<sup>26</sup>. In a Chinese study of 17,769 men aged 20–77 years, exercise habit was inversely associated with ED<sup>27</sup>. In a cross-sectional study of 1,506 men aged 26–70 years in Hong Kong, PA was significantly positively associated with ED in obese men, but not normal or overweight<sup>28</sup>.

Limited evidence exists regarding the association between PA and ED among Asian patients with type 2 diabetes mellitus. In a Chinese study of 327 men with diabetes, higher PA was significantly inversely associated with ED<sup>5</sup>. There was an inverse association between exercise habit (at least once per week) and ED in a Korean study of 1,312 men with diabetes<sup>6</sup>. However, to date, among Japanese patients with type 2 diabetes mellitus, no evidence exists regarding the association between PA and ED. The present results are partially consistent with these results that show an inverse association between PA and ED.

The mechanism of the association between PA and ED is not clear. A positive association between endothelial dysfunction and ED was reported. PA might improve ED through an increase in endothelial-derived nitric oxide<sup>29</sup> and an increase in regenerative endothelial progenitor cells<sup>30</sup>. In another respect,

**Table 3** | Crude and adjusted odds ratios and 95% confidence intervals for erectile dysfunction in relation to physical activity level

Variable	Prevalence (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Moderate-to-severe ED (SHIM <12)			
Physical activity level			
Lowest	112/167 (67.1)	1.00	1.00
Lower	82/126 (65.1)	0.92 (0.56–1.49)	1.11 (0.62–2.00)
Moderate	62/97 (63.9)	0.87 (0.52–1.48)	0.71 (0.38–1.32)
Higher	41/70 (58.6)	0.69 (0.39–1.24)	0.42 (0.21–0.85)
<i>P</i> for trend			0.02
Severe ED (SHIM <8)			
Physical activity level			
Lowest	90/167 (53.9)	1.00	1.00
Lower	65/126 (51.6)	0.91 (0.57–1.45)	1.04 (0.61–1.80)
Moderate	50/97 (51.6)	0.91 (0.55–1.50)	0.70 (0.39–1.25)
Higher	30/70 (42.9)	0.64 (0.36–1.12)	0.38 (0.19–0.73)
<i>P</i> for trend			0.005

Odds ratios were adjusted for age, body mass index, waist, duration of type 2 diabetes, current smoking, current drinking, hypertension, dyslipidemia, coronary artery disease, stroke, glycated hemoglobin, nocturia, depression, diabetic neuropathy, diabetic retinopathy and diabetic nephropathy. CI, confidence interval; ED, erectile dysfunction; OR, odds ratio; SHIM, Sexual Health Inventory for Men.

the testosterone level affects sexual dysfunction including lower sexual desire and ED. PA was inversely associated with the plasma testosterone level<sup>31</sup>. Lifestyle intervention, including PA, was effective in increasing the plasma testosterone level<sup>32</sup>, and weight reduction by exercise and diet control could improve erectile function<sup>33–35</sup>. Thus, PA might be protective against ED by increasing endothelial progenitors, improving endothelial function and increasing plasma testosterone levels. Walking habit in the present study indicates 3 METs/h<sup>36</sup>, and the amount of weekly PA was  $\geq 21$  METs/h/week. Walking habit was independently inversely associated with moderate-to-severe ED and severe ED. Both moderate PA and frequency of PA might have a protective effect on ED.

Several limitations of the present study warrant mention. PA might have a protective effect on ED among Japanese patients with type 2 diabetes mellitus. First, the present study was cross-sectional by design. In the future, an interventional study on physical activity is required to prove the protective effect of PA for ED among Japanese patients to preclude the study of the causal association between PA and ED. Second, the PA behavior, PA level and ED in the present study were based on a self-administered paper-and-pencil questionnaire. The definitions of PA in the present study were ambiguous. Answering simple questions with a standard questionnaire was validated to estimate PA using tri-axial accelerometers; the daily step count and the amount of PA at 3 METs or more among participants who answered 'Yes' to each question were higher than those who answered 'No'. A significant positive dose–response relationship between PA levels using simple questions (lowest, lower, moderate and higher) and the daily step counts, 3 METs or more and 4 METs or more, were validated in Japanese participants<sup>22</sup>. The definition of ED was based on the SHIM score (including IIEF-5) and/or National Institutes of Health

Consensus criteria<sup>37</sup> in previous epidemiological studies regarding ED. However, a previous study has proven that the SHIM score is an effective score to estimate the severity of ED<sup>38</sup>. In a previous Japanese study of 483 participants, the prevalence values of exercise habit and walking habit were 47.8% (231/483) and 53.0% (256/483), respectively. The findings of the present study were similar to previous results for a Japanese population<sup>22</sup>. Third, ED is likely to be multifactorial disorder. We could not rule out unmeasured or residual confounding factors. Fourth, SHIM scores include sexual activity and attempted intercourse. SHIM scores among patients with lower libido seemed to be lower than those among patients with normal libido. Data on sexual issues, including female partner of the patients, sexual experiences, frequency of intercourse, sexual desire, libido, delayed ejaculation and retrograde ejaculation, were not available. We could therefore not estimate the association between ED and low libido. Fifth, we did not measure serum testosterone level in the present study, even though testosterone is an important hormone to discuss in terms of sexual function. Sixth, selection bias might influence the findings in the present study. In a Japanese study of 173 patients with type 2 diabetes mellitus, the mean IIEF score was 10.0, and the prevalence values of moderate-to-severe ED and severe ED were 65.0 and 42.1%, respectively<sup>8</sup>. The mean IIEF score and the prevalence of moderate-to-severe ED in the present study were similar to those in a previous study. However, the prevalence of severe ED in the present study might be higher than those in a previous study<sup>8</sup>. Finally, most of the patients in this cohort might have opted to have an exercise habit to control their hyperglycemia and their stress.

In conclusion, PA might be independently inversely associated with ED in Japanese patients with type 2 diabetes mellitus. Further studies are required to show the beneficial effect of



physical activity on ED among patients with type 2 diabetes mellitus.

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## DISCLOSURE

The authors declare no conflict of interest.

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