Examining health literacy and healthy lifestyle characteristics as associated with glycemic control among community-dwelling Japanese people

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ABSTRACT

Background: Diabetes mellitus (DM) is strongly associated with long-term micro- and macro-vascular complications, necessitating improved glycemic control in order to reduce these complications as well as morbidity and mortality rates. Health literacy (HL) has gained considerable attention and is recognized as an important factor associated with medication adherence and health care behaviors. Few studies have assessed how health literacy (HL) and healthy lifestyle characteristics are associated with glycemic control among Japanese patients with DM. Methods: The present cross-sectional study population comprised 670 Japanese patients (446 men and 224 women) with DM who visited the Fuchu Clinic and Okamoto Medical Clinic in Tokyo, and the Taneda Medical Clinic, Tani Clinic, and Ohta Nishinouchi Hospital in Fukushima Prefecture, Japan, from December 2016 to December 2017. Self-administered questionnaires were used to collect information on HL and healthy lifestyle characteristics listed in Breslow's seven health practices. Medical information was copied from patient medical files. Results: Multivariate logistic analysis revealed a significant inverse association between the total HL score (≥ 19) and Hemoglobin A1c (Hb A1c) >7.0% compared to the total HL score (≤ 16) [Odds ratio (OR)=0.67, 95% Confidence interval (CI)=0.47-0.96)]. The total number of healthy lifestyle characteristics (≥ 6) was significantly and inversely associated with Hb A1c >7.0% compared to the total number of healthy lifestyle characteristics (≤ 3) in univariate analysis (OR=0.60, 95% CI=0.38-0.95); this significance was not observed after adjustment. Multivariate logistic analysis revealed a significant inverse association between exercise frequency ≥ 2 times per week and Hb A1c >7.0% (OR=0.64, 95% CI=0.47-0.88). Conclusions: Health literacy and adequate exercise frequency were inversely associated with uncontrolled DM, highlighting the importance of comprehensive assessments including HL, and the necessity of lifestyle modification including physical activity for maintaining better glycemic control in clinical settings.

Introduction

Non-communicable diseases (NCDs) have become a critical public health burden worldwide [1]. Diabetes mellitus (DM) is strongly associated with long-term micro- and macro-vascular complications, necessitating improved glycemic control in order to reduce these complications as well as morbidity and mortality rates [2].

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KEYWORDS

- epidemiology
- health promotion
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- lifestyle
- behavior
- health car

In particular, the number of those with DM has increased worldwide, from 108 million in 1980 to 422 million in 2014 [3]. From 1997 to 2016, the number of patients with probable DM in Japan has also increased, from 6.9 to 10.0 million, as has the number of patients with probable impaired glucose tolerance, from 6.8 to 10.0 million [4]. Although newly developed glucose-lowering agents have been introduced in recent years, the actual achievement status toward target control goal (Hemoglobin A1c [HbA1c] ≤ 6.9) as recommended by diabetes treatment guidelines remains low [5]. Effective actions focused on patient empowerment are required in addition to medication for better glycemic control.

In recent years, health literacy (HL) has gained considerable attention and is recognized as an important factor associated with medication adherence and health care behaviors [6,7]. Based on the World Health Organization (WHO) definition, a tri-level model of HL has been proposed, with both individual and population benefits assumed at each level: functional, communicative, and critical literacy [8]. Individuals with adequate HL are considered likely to adopt healthy lifestyles [9], and a brief questionnaire has been developed for easy assessment of HL [10]. However, only a few studies have examined the association between HL and healthy lifestyle characteristics among Japanese people [10-13], and reports on the association between HL and glycemic control are limited, particularly in Japan. The present study aimed to examine how HL and healthy lifestyle characteristics are associated with glycemic control among Japanese patients with DM using a concise, newly developed questionnaire.

Methods

Participants

The present cross-sectional study included 911 Japanese patients with DM who visited Fuchu Clinic and Okamoto Medical Clinic in Tokyo, and Taneda Medical Clinic, Tani Clinic, and Ohta Nishinouchi Hospital in Fukushima Prefecture, Japan, from December 2016 to December 2017.

Variables

Body height and weight were measured in the standing position. Body mass index (BMI) was calculated as body weight (kg) divided by height squared (m^2). We interviewed participants regarding their medical histories of atherosclerotic complications (cardiovascular or cerebrovascular diseases), malignant neoplasms and lifestyle-related disorders (hypertension, dyslipidemia), and family histories of other conditions (hypertension, dyslipidemia, DM, cardiovascular or cerebrovascular diseases). We then asked participants to complete self-administered questionnaires, which included HL and healthy lifestyle characteristics listed in Breslow's seven health practices, such as alcohol consumption, smoking behavior, exercise frequency, obesity (BMI), sleep duration, breakfast, and snacks between meals [14]. HbA1c and details on diabetes medications were copied from patient medical files when participants fulfilled the self-administrated questionnaires. To evaluate HL, we used a validated questionnaire that included three items for communicative HL (items i–iii) and two items for critical HL (items iv–v) [10]. These items queried whether the participant would be able to (i) collect health-related information from various sources, (ii) extract the relevant information, (iii) understand and communicate the obtained information, (iv) consider the credibility of the information, and (v) make decisions based on the information, specifically in the context of health-related issues. Participants rated each item on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). A previous study using the same questionnaire reported Cronbach's α values for communicative and critical HL scales of 0.77 and 0.65, respectively [10]. The questionnaire had only five items and was therefore easy for participants to complete. We defined healthy lifestyle characteristics as the following responses based on Breslow's seven health practices: alcohol consumption (<1 drink per day), smoking behavior (non-smoker), exercise frequency (≥ 2 times per week), BMI (18.5-24.9), sleep duration (7-8 hours), breakfast (every morning), and snacking between meals (no) [12-15].

Statistical analysis

Variables are presented as mean ± standard deviation (SD) for continuous variables or prevalence (%) for categorical variables. The target diabetic control was estimated as <7% based on the diabetes treatment guidelines recommended by the Japan Diabetes Society, and we categorized those with HbA1c ≤ 6.9% as the "controlled group" and those with HbA1c ≥ 7.0% as the "uncontrolled group" [16]. Total HL

scores were divided into three categories based on tertile (≤ 16, 17-18, ≥ 19), based on a previous study [17]. Five HL item scores were divided into two categories based on median (<4, ≥ 4). The total number for healthy lifestyle characteristics was divided into three categories based on a previous report (≤ 3, 4-5, ≥ 6) [15]. We used the t-test for continuous variables and the chi-square test or Fisher's exact test to compare proportions between sexes. To estimate the potential of HL or healthy lifestyle characteristics associated with HbA1c ≥ 7.0%, logistic regression analysis was performed using the following models. For HL, Model 1 was adjusted for age (years), sex, and total HL score (≤ 16 *vs*. 17-18, ≥ 19). Model 2 was adjusted for age (years), sex, and five HL item scores (≥ 4 *vs*. <4). As for healthy lifestyle characteristics, Model 1 was adjusted for age (years), sex, and total number of healthy lifestyle items (≤ 3 *vs*. 4-5, ≥ 6). Model 2 was adjusted for age (years), sex, and each healthy lifestyle item. All statistical analyses were performed using the Statistical Package for Social Sciences version 22 (IBM SPSS Inc., Chicago, IL, USA). P <0.05 was considered statistically significant.

■ Ethical considerations

This survey was conducted according to the Ethical Guidelines for Epidemiological Studies established by the Japanese government [18], and the Ethics Committee of Juntendo University approved the research protocol (No. 2016094). We obtained informed consent from all participants.

Results

Among 911 registered patients, 241 were excluded due to missing data for healthy lifestyle characteristics and health literacy. Ultimately, 670 were entered in the analysis as eligible participants. **TABLE 1** summarizes the basic characteristics of participants stratified by HbA1c levels. Mean age and percentage of males were 60.6 years and 66.8% in the controlled group, and 58.6 years and 66.4% in the uncontrolled group, respectively. With regard to diabetic complications, the uncontrolled group had a significantly higher presence of diabetic nephropathy, with diabetic retinopathy of borderline significance (P=0.06), relative to those in the controlled group. Among healthy lifestyle characteristics, exercise frequency ≥ 2 times per week was more common in the controlled group than in the uncontrolled group. Among heath literacy items, "Considering the credibility of the information (≥ 4)" was significantly higher, and "Understanding and communicating the information (≥ 4)" and "Making decisions based on the information (≥ 4)" were borderline significance compared to the uncontrolled group (P=0.07). **TABLE 2** shows results from

Table 1. Diabetic control specific characteristics (N=670)

	Mean (± SD) or N (%)				
Characteristics	**HbA1c ≤ 6.9 % (N=346)**		**HbA1c ≥ 7.0 % (N=324)**		***P*[a]**
Age (years)	60.6	-11.8	58.6	-12.6	
Sex (male)	231	-66.8	215	-66.4	
Anthropometric measurements					
Height (cm)	163.3	-9.1	164.4	-9.2	
Body weight (kg)	69	-15.7	70.4	-15.2	
Body mass index (BMI)	25.7	-4.8	25.9	-4.5	
Past medical history					
Cardiovascular disease	17	-8.1	27	-14.1	0.06
Cerebrovascular disease	9	-4.3	9	-4.7	
Malignant neoplasms	18	-8.6	20	-10.4	
Present medical history					
Hypertension	140	-66.7	114	-59.4	
Dyslipidemia	78	-37.1	53	-27.6	*
Family medical history					
Hypertension	158	-51.6	126	-44.4	0.08
Dyslipidemia	26	-8.5	15	-5.3	
Diabetes mellitus	189	-61.8	173	-60.9	
Cardiovascular disease	50	-16.3	53	-18.7	
Cerebrovascular disease	82	-26.8	84	-29.6	

Malignant neoplasms	141	-46.1	130	-45.8	
Diabetic complications					
Diabetic neuropathy	53	-17.2	76	-25.4	**
Diabetic retinopathy	31	-10.9	43	-16.3	0.06
Diabetic nephropathy	38	-11.3	44	-14	
Diabetic gangrene	2	-0.6	2	-0.6	
Diabetic treatments					
Hemoglobin A1c (%)	6.5	-0.3	7.8	-0.9	**
Treatment of diabetes mellitus					
Sulfonylurea	53	-17.2	85	-26.8	**
Alpha glucosidase inhibitor	27	-8.8	27	-8.5	
Biguanides	189	-61.4	227	-71.6	**
Thiazolidine derivatives	30	-9.7	48	-15.1	*
Phenylalanine derivatives	12	-3.9	11	-3.5	
Dipeptidyl peptidase-4 inhibitor	202	-65.6	173	-54.6	**
Sodium glucose transporter-2 inhibitor	52	-16.9	60	-18.9	
Glucagon-like peptide-1 receptor agonist	19	-6.2	36	-11.4	*
Insulin	38	-12.3	101	-31.9	**
Healthy lifestyle characteristics					
Alcohol consumption (non-everyday drinker)	288	-83.2	275	-84.9	
Smoking behavior (non-current smoker)	258	-74.6	250	-77.2	
Exercise frequency (≥ 2 times per week)	193	-55.8	141	-43.5	**
Body mass index (18.5-24.9)	176	-50.9	151	-46.6	
Sleep hours (6-9)	151	-43.6	133	-41	
Breakfast (every morning)	320	-92.5	306	-94.4	
Snack between meals (no)	196	-56.6	168	-51.9	
Total number of healthy lifestyle items	4.6	-1.3	4.4	-1.2	
≤ 3	76	-22	80	-24.7	*
4-5	180	-52	187	-57.7	
≥ 6	90	-26	57	-17.6	
Health literacy					
Seeking information from various sources (≥ 4)	257	-74.3	227	-70.1	
Extracting relevant information (≥ 4)	214	-61.8	205	-63.3	
Understanding and communicating the information (≥ 4)	188	-54.3	153	-47.2	0.07
Considering the credibility of the information (≥ 4)	162	-46.8	125	-38.6	*
Making decisions based on the information (≥ 4)	205	-59.2	169	-52.2	0.07
Total score	17.5	-3.6	17.2	-3.4	
≤ 16	108	-31.2	120	-37	0.06
17-18	77	-22.3	82	-25.3	
≥ 19	161	-46.5	122	-37.7	

Table 2. Logistic regression analysis of health literacy in patients with hemoglobin A1c >7.0% (N=670)

	Univariate analysis			Multivariate analysis					
				Model 1			Model 2		
Variables	OR[a]	95% CI[b]	*P*[e]	OR[a]	95% CI[b]	*P*[e]	OR[a]	95% CI[b]	P[e]
Health literacy									
Seeking information from various sources (≥ 4 *vs*. <4)	0.81	0.58-1.14		-	-		0.77	0.55-1.08	
Extracting relevant information (≥ 4 *vs*. <4)	1.06	0.78-1.45		-	-		1.04	0.76-1.42	
Understanding and communicating the information (≥ 4 *vs*. <4)	0.75	0.56-1.02	0.07	-	-		0.75	0.56-1.02	0.07
Considering the credibility of the information (≥ 4 *vs*. <4)	0.71	0.53-0.97	*	-	-		0.74	0.54-1.00	0.05
Making decisions based on the information (≥ 4 *vs*. <4))	0.75	0.55-1.02	0.07	-	-		0.78	0.57-1.06	
Total score of health literacy		-			-		-	-	
≤ 16		-							
17-18 *vs*. ≤ 16	0.96	0.64-1.44		0.93	0.62-1.40				
≥ 19 *vs*. ≤ 16	0.68	0.48-0.97	*	0.67	0.47-0.96	*			

[a]Odds ratio, [b]95% confidence interval, [c]Model 1 was adjusted for total health literacy score (<16 *vs*. 17-18 or ≥ 19), age (years), and sex; [d]Model 2 was adjusted for five health literacy items (≥ 4 *vs*. <4), age (years), and sex; [e] **p<0.01, *p<0.05

the logistic regression analysis of health literacy among those with HbA1c levels >7.0%. The total HL score (≥ 19) was significantly inversely associated with HbA1c >7.0% compared to the total HL score (total≤ 16) in Model 1 [Odds ratio (OR)=0.67, 95% Confidence interval (CI)=0.47-0.96)]. In addition, univariate analysis found that "Considering the credibility of the information (≥ 4 *vs*. <4)" was significantly and inversely associated with HbA1c >7.0% (OR=0.71, 95% CI=0.53-0.97), and borderline significance in Model 2 (OR=0.74, 95% CI=0.74-1.00, P=0.05) (**TABLE 2**). **TABLE 3** shows the results of the logistic regression analysis of healthy lifestyle characteristics among those with HbA1c >7.0%. Univariate analysis found that the total number of healthy lifestyle characteristics (≥ 6) was significantly inversely associated with HbA1c >7.0% compared to the total number of healthy lifestyle characteristics (≤ 3) (OR=0.60, 95% CI=0.38-0.95), but the significance was not observed after adjustments were made for Model 1. Among healthy lifestyle characteristics items, exercise frequency ≥ 2 times per week showed a significant inverse association with HbA1c >7.0% (OR=0.64, 95% CI=0.47-0.88) in Model 2.

Discussion

Our analysis of these cross-sectional data revealed that high HL was inversely associated with diabetic control status. Additionally, exercise frequency was found to be a protective factor leading to glycemic control among diabetic outpatients. To the best of our knowledge, this study is the first to examine how HL and healthy lifestyle characteristics are associated with diabetic control status among Japanese diabetic outpatients. Our results highlight the importance of improving HL and maintaining adequate physical activity for better glycemic control. Two studies have examined the association between HL and diabetes outcomes worldwide [17,19]. The first, a cross-sectional observational study of 408 English- and Spanish-speaking patients with DM, reported that patients with inadequate health literacy were less likely to achieve tight glycemic control (HbA_{1c} < or = 7.2%; OR, 0.57; 95% CI, 0.32-1.00; P =0.05) and were more likely to have poor glycemic control (HbA1c >or = 9.5%; adjusted OR, 2.03; 95% CI, 1.11-3.73; P=0.02) and present with complaints of retinopathy (adjusted OR, 2.33; 95% CI, 1.19-4.57; P=0.01) [17]. The second,

a six-month cross-sectional study that examined 204 Pakistani patients with diabetes, reported that the majority of patients with DM (86.1%) with poor glycemic control (HbA1C >9%) had inadequate health literacy [s-TOFHLA (Short Test of Functional Health Literacy in Adults)] and were more likely to have retinopathy (OR=13.1, P=0.003) [19]. In addition, s-TOFHLA scores were found to have a significant association with HbA_{1c} levels [adjusted coefficients –0.0387 (–0.125 to –0.032), P=0.001] after adjusting for basic characteristics [19]. With regard to the mechanism driving the relationship between HL and glycemic control, the Special Diabetes Program for Indians Healthy Heart Demonstration Project suggested that knowledge was the main driver of the relationship between HL with HbA_{1c} [20]. Consistent with these previous studies, the present study revealed a significant association between HL and glycemic control status, as well as the possibility that high HL might contribute to better management of diabetic control among our participants. Notably, one cross-sectional study of 1,002 English-speaking adults with DM found no association between health literacy and glycemic control (beta coefficient, +0.001; 95% CI, -0.01 to +0.01; P=0.88), systolic blood pressure (beta coefficient, +0.08; 95% CI, -0.10 to +0.26; P=0.39), diastolic blood pressure (beta coefficient, -0.03; 95% CI, -0.12 to +0.07, P=0.59), or low density lipoprotein (beta coefficient, +0.04; 95% CI, -0.27 to +0.36, P=0.77) [21]. Thus, the association between HL and glycemic control may be still controversial, necessitating additional studies to examine its relationship with health outcomes over time. In the present study, univariate analysis revealed that a total of 6 or 7 healthy lifestyle characteristics was protective against uncontrolled glycemic status, and that adequate exercise frequency was significantly and inversely associated with uncontrolled glycemic status after adjustment. It is well-known that healthy lifestyle choices contribute to improved management of glycemic control, and diabetes management guidelines have emphasized lifestyle modification as a way to improve management of diabetes mellitus [22]. The Ningen Dock Database Group examined 7,020 Japanese with diabetes mellitus at their annual health check-up and found that the mean HbA1c level was 7.3% (56 mmol/mol), and that the odds ratios for smoking, exercise and dietary habits were

Table 3. Logistic regression analysis of healthy lifestyle characteristics in patients with hemoglobin A1c >7.0% (N=670)

	Univariate analysis			Multivariate analysis					
				Model 1			Model 2		
Variables	OR[a]	95% CI[b]	*P*[e]	OR[a]	95% CI[b]	*P*[e]	OR[a]	95% CI[b]	P[e]
Healthy lifestyle characteristics									
Alcohol consumption (non-everyday drinker)	1.13	0.75-1.71		-	-		1.07	0.69-1.64	
Smoking behavior (non-current smoker)	1.15	0.81-1.64		-	-		1.27	0.88-1.84	
Exercise frequency (≥ 2 times per week)	0.61	0.45-0.83	**	-	-		0.64	0.47-0.88	**
Body mass index (18.5-24.9)	0.84	0.62-1.42		-	-		0.92	0.67-1.26	
Sleep hours (6-9)	0.9	0.66-1.22					0.97	0.71-1.33	
Breakfast (every morning)	1.38	0.74-2.57					1.49	0.80-2.80	
Snack between meals (no)	0.82	0.61-1.12					0.82	0.59-1.12	
Total number of healthy lifestyle items		-							
≤ 3									
4-5 *vs.* ≤ 3	0.99	0.68-1.44		1.04	0.71-1.52				
≥ 6 *vs.* ≤ 3	0.60	0.38-0.95	*	0.68	0.42-1.09				

[a]Odds ratio, [b]95% confidence interval, [c]Model 1 was adjusted for total number healthy lifestyle items (<3 *vs.* 4-5 or ≥ 6), age (years), and sex; [d]Model 2 was adjusted for seven healthy lifestyle items, age (years), and sex; [e] **p<0.01, *p<0.05

significantly higher for those with poor glycemic control (HbA1c ≥ 7%) than for those with good glycemic control (HbA1c <7%) [23]. A cross-sectional survey that aimed to explore the association between the degree of adherence to recommendations and diabetes management among 726 Korean subjects with DM found that subjects who fulfilled 5 or more of the 10 lifestyle recommendations showed significantly lower blood lipid parameters and glycated hemoglobin levels than those who did not. In addition, of the 10 lifestyle recommendations, physical activity had the lowest adherence rate [24]. Exercise is widely endorsed in the literature and in clinical support systems as a way to positively impact and improve glucose control among patients with DM [25]. If HbA1c levels are affected, then a 0.5 to 1.0% decrease is typically noted; in the context of therapeutic efficacy, this would be considered modest [25-27]. Therefore, the importance of maintaining healthy lifestyle characteristics, including an adequate exercise frequency, should be emphasized more in order to improve management of glycemic control.

The present study has several limitations worth noting. First, there may have been selection bias, as study participants were recruited from among those who had visited several Japanese diabetes specialized clinics. Thus, these participants may have had higher health awareness and better healthy lifestyle characteristics compared to other patients with DM. Large-scale studies spanning multiple regions in Japan and include individuals who have been treated at diabetes non-specialized institutions will be needed in the future. Second, as HL and lifestyle characteristics were assessed based on self-reported questionnaires, our participants may have reported better HL and healthier lifestyles than are actually true, which may have resulted in an over-estimation of HL and health characteristics. Third, given the cross-sectional design, we could not determine whether there was a causal relationship between HL and healthy lifestyle characteristics. A longitudinal study will be needed to address this. Fourth, while the information collected from participants contained a comprehensive set of clinical variables, several important factors, especially educational, income statuses and well-being, were not measured. Also, insulin secretory capacity was not estimated and pharmacological characteristics were not considered in the present study. Lastly, sample size calculation was not conducted prior to main survey, because number of participants was depending on number of patients who visited to these institutions.

Conclusions

Our study revealed that health literacy and adequate exercise frequency were inversely associated with uncontrolled DM. These findings highlight the importance of comprehensive assessments including HL, and the necessity of lifestyle modification including physical activity for maintaining better glycemic control in clinical settings.

Acknowledgments

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Competing interests

The authors declare that they have no competing interests.

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