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ORIGINAL RESEARCH

Association Between Physical Activity and Type 2 Diabetes Using the International Physical Activity Questionnaires: A Case-Control Study at a Health Promoting Hospital in Chiang Mai, Northern Thailand

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Background: Health education and promotion is active in Thailand where diabetes is prevalent at 11.6% of the general adult population in 2021.

Purpose: This study aimed to describe and compare the levels of physical activity between patients with newly diagnosed diabetes and non-diabetic controls in northern Thailand.

Methods: This observational case–control study included participants aged between 25 and 74 years in Chiang Mai. We recruited 150 patients with type 2 diabetes mellitus (T2DM) at Sanpatong District Hospital and 150 control participants (non-T2DM) in the community. Interviews were conducted using the International Physical Activity Questionnaires–Short Form. Anthropometric measurements and social demographic information were collected from both patients and controls in 2019.

Results: The mean age of the participants was 58.8 ± 8.4 years in the T2DM group and 56.5 ± 9.9 years in the non-T2DM group. Compared to controls, patients with T2DM had received significantly more physical activity education ($P < 0.001$, Fisher's test). Most cases (93.3%) had received such education at a hospital or health center. The median total metabolic equivalents (METs) minutes per week (min/week) for participants in the T2DM group were higher than those in the non-T2DM group (2726 vs 1140 METs min/week) ($P < 0.001$, Mann–Whitney test). Comparing the case and control groups in the category of PA level, we found that the case group had a higher proportion of high-level physical activity ($P < 0.001$, chi-square test).

Conclusion: Diabetes patients attending a community hospital exhibited high levels of physical activity. The majority of them received education related physical activity from a primary health care service.

Keywords: diabetes mellitus, DM, health education, physical activity, international physical activity questionnaires, IPAQ, Thailand

Introduction

Diabetes mellitus (DM) is one of the most common non-communicable diseases and poses a major public health burden worldwide.[1,2] The International Diabetes Foundation estimates that, globally, approximately 463 million people lived with DM in 2019, and by 2045 this number is estimated to rise to 700 million.[3] The prevalence of DM is rising more rapidly in low- and middle-income countries (LMICs) than in high-income counties.[4] Thailand is an upper-middle-income country in

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southeast Asia and has a high prevalence of DM.[5] Over 90% of patients with DM have type 2 DM (T2DM) that places a huge burden on healthcare systems.[6] In Thailand, the prevalence of T2DM among adults has increased from 7.5% in 2009[7] to 11.6% in 2021.[1,8] Considering that the risk factors for T2DM include an age of 45 years or older, body mass index (BMI) over 25 kg/m^2, high blood pressure, energy-dense Western-style diet, reduced or disturbed sleep, smoking, stress, depression, low socioeconomic status, and low levels of physical activity (PA), lifestyle interventions have been strongly recommended.[6,9–11] A randomized trial for a community-based diabetes prevention program in Thailand revealed that community-based participatory group activities could prevent or delay the incidence of diabetes among those with impaired glucose tolerance.[12]

Several epidemiological studies have reported a significant negative association between PA level and the incidence of metabolic syndrome in adults.[13,14] PA has been shown to affect the prevention of DM by increasing insulin sensitivity and mitigating glucose intolerance.[15] A systematic review and meta-analysis suggested that an increase in PA decreased T2DM incidence by 26%.[16] However, individuals find it difficult to change their lifestyle with regard to PA. Changes in transportation, leisure, and home production have been associated with reduced PA and increased sedentary time, and options for increasing energy expenditure through PA may be limited in LMIC.[17] Topothai et al in Thailand showed that the mean daily steps of adult participants were far below the recommended PA level and that females, younger participants, persons with obesity, and rural residents had significantly lower mean daily steps than their counterparts.[18] Thanamee et al estimated that approximately 25% of the Chiang Mai population were physically inactive throughout 2014.[19] Thus, programs that not only teach patients with T2DM the importance of PA but also aid in changing their lifestyle and increasing their actual PA are important in northern Thailand.

Thailand has been active in promoting health education such that the parliament has enacted the Health Promotion Foundation Act in 2001.[20] Farmers in northern Thailand had been found to exhibit higher health literacy compared to those from several other Asian countries.[21] The current practice of diabetes care in the district and primary healthcare level of Thailand has been provided based on clinical practice guidelines and diabetes care guidelines at district health network level.[22,23] District hospitals serve to provide the care for diabetes cases while follow-up of the diabetes patients is served by the primary healthcare services at village level. Their lifestyle modification is educated at district hospitals, and also continued at primary healthcare services. Moreover, persons at the risk of T2DM such as aged over 40 years, those with family history are regularly screened annually at the primary healthcare centers. Diabetes care services are covered by the national health insurance scheme for all Thai citizens. According to the current guidelines, promoting PA is a compulsory service in addition to medication, follow-up and prevention of diabetes complication. The current study being located at a district in northern Thailand, consisted of patients who are diagnosed and receiving such services for a period less than six months as cases and people without diagnosis and living in the same district as controls. Since there is a literature gap demanding a study which measures the level of PA and compares between diabetes and non-diabetes, we purposely assembled the study and applied international physical activity questionnaires (IPAQ).

The International Physical Activity Questionnaire–short form (IPAQ-SF) developed by the WHO in 1998 is a common measurement tool for PA with seven questions. PA was categorized using the IPAQ scoring protocol.[24] The IPAQ-SF has been used previously for the evaluation of PA with T2DM.[25–27] In Thailand, one study used the IPAQ-SF to determine the preliminary validity of its PA questionnaire specifically designed for patients with chronic stroke called SPAQ.[28] Although there are various studies related to PA and T2DM in Thailand, no previous study has used the IPAQ-SF for the concrete evaluation of PA level in Thai patients with T2DM.

Our study aimed (1) to measure the level of PA among patients with T2DM, (2) to compare the level of PA between diabetes and non-diabetes participants, and (3) to identify an association between different degrees of PA and the status of diabetes in cross-sectional observation.

Methods

Study Design

It was conducted in a case–control study design. A total of 300 participants consisted of 150 cases (patients with T2DM) and 150 controls (persons without T2DM). The study period was between 2019−2020.

Case and Control Definitions

Eligibility Criteria

Eligibility criteria were set to define the domain of the study population such as age 25–74 year, either sex, residents in the same Sanpatong district, Chiang Mai province, Thailand. Both cases and controlled group participants met eligibility criteria. In addition, participants in each group were defined to have a clear difference of outcome status "T2DM" between the cases and controls (Figure 1, Table 1). Potential participants were asked to take part in the study if they could voluntarily provide informed consent. An appointment was arranged for a personal interview to obtain information if the patient met the selection criteria and agreed to participate.

Cases Definition

Cases were defined as diabetes patients who were diagnosed within six months before data collection and had been attending the diabetes clinic of Sanpatong District Hospital. The diagnosis of T2DM followed Thailand national guideline for diabetes such as fasting plasma glucose level more than 126 mg/dL (7.0 mmol/L) or 2 hours OGTT level more than 200 mg/dL (11.1 mmol/L).[22] Newly diagnosed diabetes patients attending Sanpatong diabetes clinics were screened by applying the eligibility criteria and cross-checked with their medical records before being invited to interviews.

Control Definition

Controls in this study were "community controls" who met the criteria for eligibility and the status of diabetes has been ruled out by a negative result of a diabetes test before recruitment. Control participants were recruited in the community setting at the villages through a diabetes screening process. We selected the participants from one of the sub-districts, primary care setting, under Sanpatong District Hospital. Diabetes-free status among controls was verified by negative results of plasma glucose test, which is used in routine diabetes screening. If an eligible control consented to participation, they were interviewed using the same questionnaire.

Study Setting

The current study was conducted at Sanpatong district in Chiang Mai, Thailand. Surrounding Sanpatong District Hospital, there are around 20 primary care units (PCUs) that have been conducting free routine health checkups once a year at the community level for over 40 years. Those suspected of having T2DM were invited to Sanpatong District Hospital for further checkups and a final diagnosis. Soon after diagnosis, the hospital provides education programs via the nurses, first through individual counseling and then through several group lessons for the appropriate lifestyle to treat T2DM. These lessons were provided periodically. After the patients become stable for T2DM, they went back to the PCUs where they continued to receive treatment.

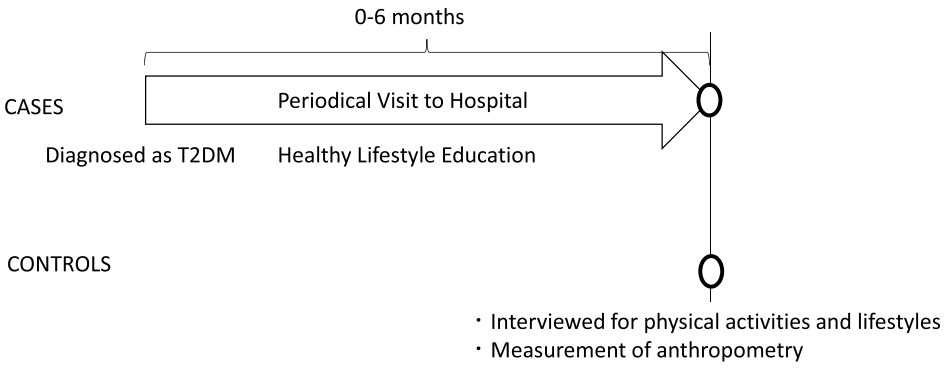

Figure 1 Data collection procedure for samples (cases and controls).

Table 1 Inclusion and Exclusion Criteria

	Case	Control
Inclusion	•Age: 25–74 years. •Either sex. •All races and religions. •Being able to undertake a face-to-face interview including measurements. • Newly diagnosed T2DM Patients attending Sanpatong district community hospital who were diagnosed within six months before data collection. • Diagnosed as T2DM according to Thailand national guideline for diabetes such as fasting plasma glucose level more than 126 mg/dL (7.0 mmol/L) or two hours OGTT level more than 200mg/dL (11.1 mmol/L).	•Age: 25–74 years. •Either sex. •All races and religions. •Being able to undertake a face-to-face interview including measurements. •Community residents who are not diabetes. • The diagnosis of diabetes was excluded by blood glucose screening test that is routinely used for health checkup.
Exclusion	•Non-residents, tourists, or foreigners •Those not willing to participate •Those diagnosed with chronic diseases like kidney failure	

Sample Size

We recruited 150 cases and 150 controls. STATA version 15.1 (Stata Corporation, College Station, TX) was utilized for power analysis for two-sample means tests. The precision levels applied were a *P* value of 0.05 and a 95% confidence interval, and the estimated power for the comparison of total METs min/week between two groups was 0.719.

Data Collection

Face-to-face interviews were conducted using the standardized IPAQ-SF questionnaire. Anthropometric measurements, including weight and height, were collected from cases and controls. All participants that met the eligibility criteria for the case and control groups were recruited until the number of required samples was reached in 2019.

Translation of Questionnaires

The translation and adaptation process of the survey instrument and consent cover letter followed the WHO guideline on translation.[29] The original English set of questionnaires, including the IPAQ-SF, was translated into Thai by a panel of native experts. The translation process was as follows: forward translation, reverse translation, and pilot testing for the final version. For the pilot test, prior to this survey, a pretest using the same questionnaire was conducted on 30 Thai nationals to confirm the accuracy of the translation of the questionnaire into Thai.

IPAQ-SF Scoring

The METs min/week of a specific activity (vigorous, moderate, and low-intensity PA) was calculated by multiplying the MET value of a particular activity (3.3 for walking, 4.0 for moderate PA, and 8.0 for vigorous PA) by the minutes spent doing that particular activity (eg, walking METs min/week = 3.3 × walking minutes × walking days).[24] Only activities that lasted at least 10 minutes were taken into account. The PA was categorized using the IPAQ scoring protocol. The current guidelines for PA in the IPAQ scoring protocol categorizes PA level into three groups: 1, "low" (some activity is reported but not enough to meet categories 2 or 3); 2, "moderate" (meets any of the following three criteria: (a) 3 days of vigorous activity for at least 20 min/day; (b) 5 days of moderate-intensity activity or walking for >30 min/day for >10 min at a time; or (c) 5 days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving at least 600 METs min/week); and 3, "high" (meets either of two criteria: (a) vigorous-intensity activity on >3 days/week, accumulating at least 1500 METs min/week; or (b) >5 days of any combination of walking, moderate-intensity, or vigorous-intensity activities achieving at least 3000 METs min/week). The criteria was based on the standard scoring criteria.[24]

Statistical Analysis

The distribution of outcome variable, exposure variable and covariates were summarized based on the nature of the data. The comparison of categorical variables was analyzed by applying the chi-square test. Continuous variables such as total METs min/week, blood pressure, BMI, and waist circumferences were summarized descriptively after categorization based on the guideline and normal values.

The chi-square test and Fisher's exact test were conducted for the characteristics of study participants: age (under 60 years vs 60 years and older), sex (male vs female), marriage status (currently not married including single and divorced vs currently married), level of education (no formal schooling vs primary, secondary, or high school completed), income sufficiency for living expenses (insufficient vs sufficient), average household monthly income (<20,433 vs ≥20,433 baht/month), family diabetes history (no vs yes), hypertension (no vs yes), alcohol (never, quit, and regularly), smoking (never, quit, and regularly), BMI (<25 vs ≥25), and high waist circumference (waist ≥90 cm for men and waist ≥80 cm for women: no vs yes). BMI cutoff is defined by WHO definition of overweight that is a BMI greater than or equal to 25.[30] High waist circumference cutoff is defined by International Diabetes Federation's guideline for metabolic syndrome that is waist ≥90 cm for men and waist ≥80 cm for women in south-east Asians.[31,32] Average household monthly income is used following previous existing data, and the average household monthly income in Chiang Mai for 2019 was used as the cutoff.[33]

In this study the amount of PA was the main exposure variable of interest. First, the amount of PA was compared between the cases and control group. The distribution of the data was checked by using the Shapiro–Wilk test of normality. It was not in the normal distribution. Therefore, the Mann–Whitney test was applied to compare the amount of PA between the two groups.

This study analyzed PA education received by the participants, and the level of their PA. The level of PA among patients with and without T2DM, such as the total METs min/week, the METs min/week for each activity level, and PA level groups, were compared using the Mann–Whitney test and chi-square test. Finally, the PA level groups were compared between cases and controls after the adjustment. Variables were selected mainly from cases and controls that showed significant differences during univariate analyses considering the influencing factors based on previous research, such as sex, BMI, age, and average household monthly income.

In this case-control study, the outcome variable was diabetes status which is coded as binary data. Therefore, we chose multiple logistic regression analysis. At first, statistical association of exposure variable and each covariate to the outcome variable was analyzed using the binary logistic regression, reporting odds ratio (OR) and 95% confidence interval (95% CI). Then the selected variable underwent multiple logistic regression analysis. Selection was based on p value of 0.2 and conceptual relevance. It consisted of PA level, age, gender, BMI and income level. The final model reported adjusted odds-ratio (aOR) and 95% CI.

Statistical significance was defined as P values less than 0.05, with 95% confidence interval.

Ethical Approval

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human patients were approved by the Ethical Review Committee for Research on Human Participants, Chiang Mai Provincial Health Office and Ethical Review Board of the Juntendo University, Tokyo (authorization number 2017141).

Results

The Characteristics of Participants

The sample of 300 participants consisted of Thai citizens. Average age did not differ significantly between the cases and controls (58.8 ± 8.4 years vs 56.5 ± 9.9 years) (Table 2). Male proportion was higher in the cases than in the controls (53.3% vs 43.3%) (Table 2). In addition, the case group included a significantly higher proportion of participants with a higher average household monthly income (P = 0.035, Fisher's exact test), family diabetes history (P < 0.001, chi-square test), and hypertension (P < 0.001, chi-square test), and lower proportion of participants with alcohol intake (P = 0.004, chi-square test), compared to the control group. There was no difference in the marital status, level of education, income sufficiency for living expenses, smoking status, BMI, and waist circumference between the two groups.

Table 2 Characteristics of Study Participants (n = 300)

Variables	Control (n = 150) (%)	Case (n = 150) (%)	Value $\chi 2$	P-value
Age				
Under 60 years	85 (56.7)	73 (48.7)	1.93	0.165
60 years and older	65 (43.3)	77 (53.3)		
Sex				
Male	41 (27.3)	63 (42.0)	7.12	0.008[a]
Female	109 (72.7)	87 (58.0)		
Marriage status				
Currently not married	43 (28.7)	41 (27.3)	0.07	0.797
Currently married	107 (71.3)	109 (72.7)		
Level of education				
No formal schooling	19 (12.7)	13 (8.7)		
Primary, secondary, or high school completed	131 (87.3)	137 (91.3)	1.26	0.262
Income sufficiency for living expenses				
Insufficient	72 (48.0)	83 (55.3)	1.62	0.204
Sufficient	78 (52.0)	67 (44.7)		
Average household monthly income (Baht/month)[b]				
< 20,433	148 (98.7)	140 (94.0)	4.67	0.035[a]
≥ 20,433	2 (1.3)	9 (6.0)		
Family diabetes history				
No	128 (85.3)	95 (63.3)	19.03	<0.001[a]
Yes	22 (14.7)	55 (36.7)		
Hypertension[c]				
No	95 (65.5)	29 (19.3)	64.5	<0.001[a]
Yes	50 (34.5)	121 (80.7)		
Alcohol intake				
Currently not drinking	92 (61.3)	115 (76.7)	8.24	0.004[a]
Regularly drinking	58 (38.7)	35 (23.3)		
Smoking				
Currently not smoking	133 (88.7)	131 (87.3)	0.13	0.722
Regularly smoking	17 (11.3)	19 (12.7)		
BMI				
<25	92 (61.3)	85 (56.7)	0.68	0.411
≥25	58 (38.7)	65 (43.3)		
High Waist Circumference [d]				
No	60 (40.3)	51 (34.0)		
Yes	89 (59.7)	99 (66.0)	1.26	0.262

Notes: [a]P-value is less than 0.05. [b]For average household monthly income, one case data is missing. [c]Those who had high blood pressure at the time of visiting the hospital and those who had taken medicine to treat raised blood pressure during the past two weeks were categorized as hypertension. [d]High Waist Circumference defined as waist ≥90 cm for male and waist ≥80 cm for female. One case data is missing for waist circumference.

The Source of Education Related to PA

Table 3 and Figure 2 show the education related to PA among participants. Table 3 shows that in the cases group, significantly more participants had received PA education compared to controls (P < 0.001, Fisher's exact test). Figure 2 shows the sources from which participants received education related to PA. Most patients with T2DM (93.3%) had received PA education at a hospital or health center. Some cases and controls received PA education from the television,

Table 3 The Proportion of Receiving Education Related Physical Activity (PA) (n = 300)

Variables	Control (n = 150) n (%)	Case (n = 150) n (%)	P-value
Have you ever received education related to PA?			
No	31 (20.7)	3 (2.0)	<0.001[(a)]
Yes	119 (79.3)	147 (98.0)	

Note: [(a)]P-value is less than 0.05.

internet, radio, school and newspapers. The proportion of those receiving PA-related education from school was <10% among both cases (2.7%) and controls (7.3%), respectively.

Comparing the Amount and Level of PA

Table 4 shows the amount and level of PA of the participants. The median total METs min/week for the cases were 2726 METs min/week (interquartile range [IQR]: 1314–4746), which was significantly higher than the median total METs min/week for the controls (1140 METs min/week, IQR: 198–3000) ($P < 0.001$, Mann–Whitney test). (Table 4, Figure 3) When we consider the median total METs min/week among the cases, there were no significant differences between those who answered they received PA education at a health center or hospital and those who did not (Figure 2).

Figure 4 shows the comparison of the METs min/week from walking, moderate exercise, and vigorous exercise between the case and control groups. Specifically, the frequency of vigorous activities (eg, digging, fast cycling, heavy lifting, or aerobics) and walking was significantly higher among the case group than among the control group ($P < 0.001$, Mann–Whitney test) (Table 4, Figure 4).

Comparing the case and control group in the category of PA level, we found that the case group had a higher proportion of high-level PA and a lower proportion of low-level PA compared to the control group ($P < 0.001$, chi-square test). In total, 33.3% of the participants in the control group were categorized as having a high PA level, while 55.3% of the participants in the case group were categorized as having a high PA level.

Results of Multiple Logistic Regression Analysis Applying Diabetes as Dependent Variable

Univariate analysis results show that that the cases group were found to be physically more active than the control participants. In addition, male gender (OR 1.93, 95% CI 1.19–3.21) and participants belonging to the family with above average monthly income (OR 4.76, 95% CI 1.01–22.4) were more likely to be diabetic. Multivariate analysis, adjusting for significant covariates, indicates that those with higher levels of PA were more likely to be diabetes patients. The case

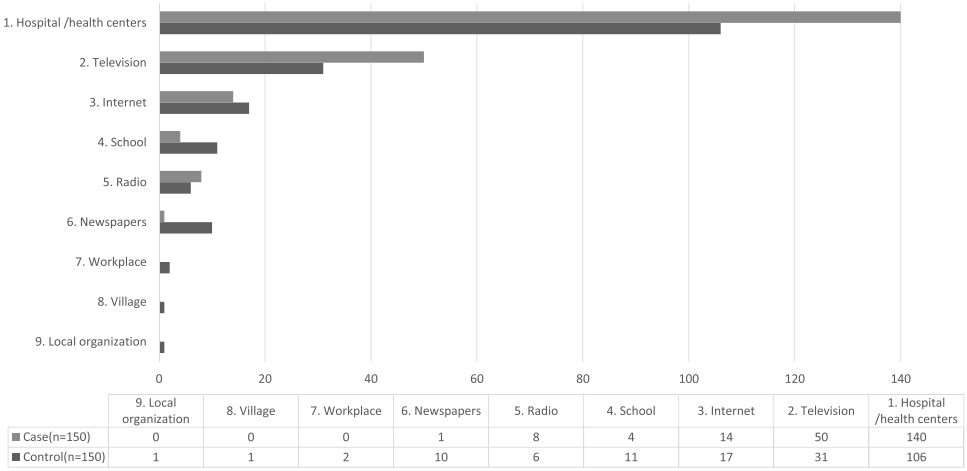

Figure 2 The sources from which participants received education related to physical activity (n = 300, multiple answers).
Note: Sources are not mutually exclusive.

Table 4 The Amount and Level of Physical Activity of the Participants (n = 300)

Physical Activity	Total (N = 300)	Control (n = 150)	Case (n = 150)	P-value
Total METs min/week				<0.001[a]
Mean ± SD	3563.3 ± 5051.4	2826.9 ± 4414.2	4299.8 ± 5534.2	
Median (IQR)	1795.0 (592.5–4075.5)	1140.0 (198–3000)	2726.3 (1314–4746)	
Vigorous METs min/week (8.0 METs)				<0.001[a]
Mean ± SD	1699.2 ± 4148.5	1057.6 ± 3138.3	2340.8 ± 4884.4	
Median (IQR)	480.0 (0.0–1320.0)	0.0 (0.0–720.0)	720.0 (0.0–1800.0)	
Moderate METs min/week (4.0 METs)				0.236
Mean ± SD	608.3 ± 1145.6	753.6 ± 1455.3	463.1 ± 687.9	
Median (IQR)	240.0 (0.0–840.0)	240.0 (0.0–840.0)	240.0 (0.0–720.0)	
Walking METs min/week (3.3 METs)				<0.001[a]
Mean ± SD	1255.8 ± 1994.3	1015.7 ± 2368.7	1495.9 ±1501.4	
Median (IQR)	495.0 (66.0–1386.0)	140.3 (0.0–693.0)	1386.0 (396.0–2079.0)	
PA level group (N (%))				<0.001[b]
Low	74 (24.7)	51 (34.0)	23 (15.3)	
Moderate	93 (31.0)	49 (32.7)	44 (29.3)	
High	133 (44.3)	50 (33.3)	83 (55.3)	

Notes: [a]P-value is less than 0.05 by Mann–Whitney test. [b]P-value is less than 0.05 by chi-square test.

group had a significantly higher proportion of high-level and moderate-level PA compared with low-level PA after adjustment for sex, BMI, age, and average household monthly income (moderate-level PA: OR 2.04, 95% CI 1.06–3.94, high-level PA: OR 3.67, 95% CI 1.96–6.87) (Table 5).

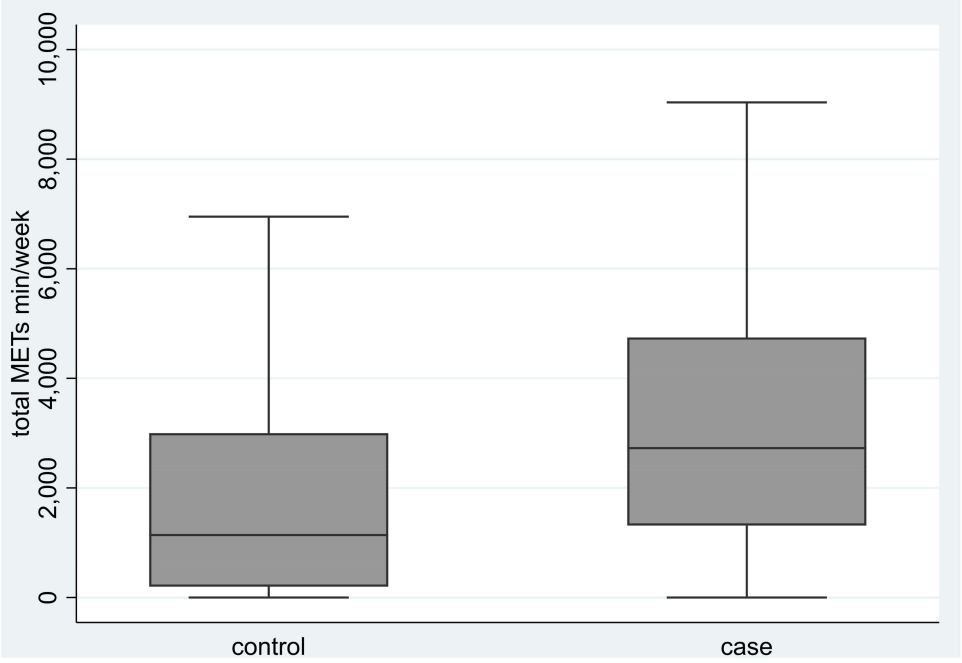

Figure 3 Total METs min/week among those with and without diabetes (n = 300).
Note: Excludes outside values.
Abbreviation: METs: the metabolic equivalents.

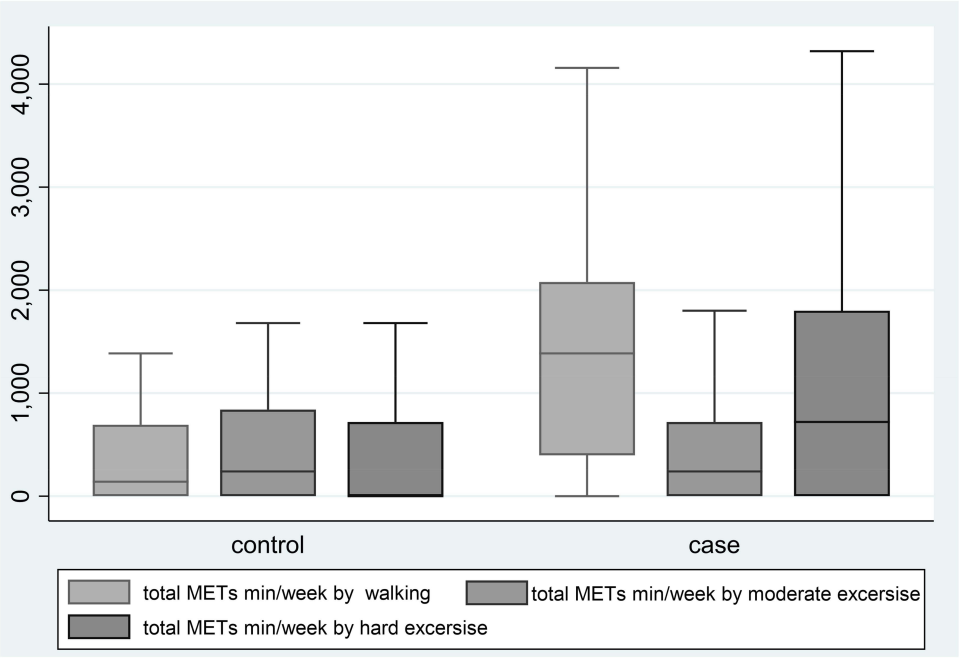

Figure 4 METs min/week from walking, moderate exercise, and vigorous exercise among patients with diabetes and the non-diabetes control group (n = 300).
Note: Excludes outside values.
Abbreviation: METs: the metabolic equivalents.

Discussion

National diabetes care guidelines and primary care network guidelines in Thailand showed that promoting PA is a compulsory component in the management of T2DM in Thailand.[22] The current study was conducted in such a primary care setting where diabetes clinics of district hospitals provides treatment and lifestyle education, especially PA promotion. In this study, we applied the IPAQ-SF to accurately measure the PA level of diabetes patients who were receiving lifestyle education, as a compulsory component in the diabetes care service. We also measured PA level of community controls who were not diabetic and thus, not receiving education for diabetes specific lifestyle changes. This observational study was carefully designed as a case-control study applying

Table 5 Factors Associated with Diabetes Between Cases and Controls Through Multiple Logistic Regression Analysis (n = 300)

Variable	Total = 300	Control = 150	Case = 150	Univariate Analysis		Multivariable Analysis[(b)]	
		N (%)	N (%)	OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
Low PA	89	56 (62.9)	33 (37.1)	Ref		Ref	
Moderate PA	78	44 (56.4)	34 (43.6)	1.99 (1.05–3.77)	0.035[(a)]	2.04 (1.06–3.94)	0.034[(a)]
High PA	133	50 (37.6)	83 (62.4)	3.68 (2.01–6.74)	<0.001[(a)]	3.67 (1.96–6.87)	<0.001[(a)]
Female	196	109 (55.6)	87 (44.4)	Ref		Ref	
Male	104	41 (39.4)	63 (60.6)	1.93 (1.19–3.21)	0.008[(a)]	1.52 (0.91–2.55)	0.110
BMI < 25	177	92 (52.0)	85 (48.0)	Ref		Ref	
BMI ≥ 25	123	58 (47.2)	65 (52.8)	1.21 (0.77–1.92)	0.411	1.23 (0.75–2.01)	0.406
Age < 60	158	85 (53.8)	73 (46.2)	Ref		Ref	
Age ≥ 60	142	65 (45.8)	77 (54.2)	1.38 (0.88–2.17)	0.166	1.61 (0.99–2.62)	0.056
Average household monthly income (Baht/month)							
<20,433	288	148 (51.4)	140 (48.6)	Ref		Ref	
≥20,433	11	2 (18.2)	9 (81.8)	4.76 (1.01–22.4)	0.049[(a)]	4.34 (0.88–21.39)	0.071

Notes: [(a)]P-value is less than 0.05. [(b)]Adjusted for sex, BMI, age, and average household monthly income.

definitions of "case" and "control", eligibility criteria, two sample approach in sampling and sample-power calculation. The control group in this study is community control thus it reveals the risk factors as naturally prevalent in the community setting. The difference in PA level between cases and control were investigated with a two-tailed hypothesis.

Comparing PA level between those two groups, we found out that patients with T2DM diagnosed within six months were physically more active than the non-diabetes community controls (Table 4, Figure 3). After adjusting for the covariates such as socio-demographic characteristics, the difference between the two groups remained statistically significant (Table 5). Longer and more frequent periods of PA, especially walking and vigorous activity were obviously more common among the diabetes patients (Table 4, Figure 4). In the study setting, PA promotion is a component of standard guideline for diabetes patients.[22] We chose early cases who were diagnosed within the previous six months of data collection according to the definition of new diabetes. There is a chance of PA promotion due to diabetes education delivered by diabetes clinic and primary healthcare. In contrast, controls who lacked diabetes status may not receive the intensive lifestyle change messages and education like diagnosed cases. It may have led the research to find out the higher level of PA among the diabetes "cases".

Distribution of demographic characteristics and health risk behaviors revealed the statistically significant differences between the two groups whilst age, BMI and waist circumference and smoking rate were not significantly different. The cases "diabetes" group had a higher proportion of males and higher incomes. One third of them had a family history of diabetes. More than 80% of them had high blood pressure (Table 2). Existing literature agreed that there was a tendency of hypertension as a comorbid disease among those with diabetes.[34]

The previous Thai cohort study investigating risk factors exposed before the onset of diabetes showed among men, regular alcohol intake was associated with increased T2DM risk.[35,36] In the current study, alcohol consumption, in terms of regular drinking, is less among the cases than the controls (Table 2). It might be because of behavior modification as an aftermath of diabetes diagnosis and consequent intensive health education. This is further supported by the finding that almost all the diabetes patients 98% vs 79% of non-diabetes persons have received education related to PA ($P < 0.0001$, Table 3). Therefore, the reason why there is a higher level of PA among cases can be explained in a similar way.

According to Bauman et al, the percentage of those with high PA level in 20 countries, including both developing and developed countries, varied from 21.2% in Japan to 63.1% in New Zealand.[37] Compared to these 20 countries, our findings showed that more cases (55.3%) had high PA level as shown in Table 5. However Thanamee et al reported a low level of physical inactivity among general Chang Mai population, in a previous study.[19] It agreed with the lower level of PA that we identified in the community control group. The question can be raised where physical education starts in Thailand. The findings of the current study highlighted that PA promotion should be launched as a population approach instead of a high-risk approach focusing on diagnosed cases of diabetes.[38] Environmental factors such as neighborhood walkability and accessibility to sports and gyms plays a large role.

Moreover, the source of education as reported by diabetes patients were medical facilities, ranking 1st (Table 3 and Figure 2). After cases were diagnosed with T2DM for the first time and before they were interviewed, they had visited the medical facilities periodically and been provided with education for T2DM. If the patients were poorly controlled, they were monitored every two weeks, and assigned a variety of activities to engage in such as exercise and games intended to promote PA. These findings altogether pointed out that the exposure to diabetes care services for a period of six months might have promoted the PA. In a study in Myanmar conducted by our research teams with the same study design, patients with T2DM had a lower PA level compared to non-T2DM participants.[27] The difference between our results and those presented in the Myanmar study may be attributed to effects of education from healthcare personnel in Thailand.

Male gender was more likely to be diabetic in the univariate analysis but the association was not significant in the adjusted model in this study (Table 5). Although T2DM was more frequently diagnosed at lower BMI and age in male gender, the most important risk factor, obesity, is also common in the female gender.[39] The previous studies did not find a statistically significant difference in T2DM by gender both in the whole of Thailand and in northern Thailand.[40,41]

Thailand has strong support in communities to improve health behaviors. The village health volunteers have been a regular part of Thailand's health system since the 1960s.[42] Although Thailand has a shortage of community health nurses to support the self-management of T2DM,[43] some evidence has addressed the effectiveness of the programs conducted by community healthcare workers in Thailand.[44–46] In this study site, the patients diagnosed with T2DM received prescription and treatment, lifestyle education, including behavioral therapy from doctor-led diabetes clinics at the district hospitals and subsequently they receive monthly follow-ups at nurse-led primary healthcare services at PCU and several community based activities for PA promotion and a healthy lifestyle. Sanpatong District Hospital supervised around 20 PCUs. Nurses in the PCUs supervised village health volunteers at these sites who help staff members at PCUs to provide care, including encouraging T2DM patients in the community to maintain a healthy lifestyle. Poorly controlled diabetes patients are referred back to Sanpatong District Hospital. Annually all patients went to Sanpatong District Hospital to receive essential laboratory examinations. In Thailand, for example, brief group cognitive behavioral therapy and pictorial diary handbook programs have been shown to be effective for patients with T2DM.[47,48] This continuous support for patients with T2DM between district hospitals and PCUs could be effective to maintain their health and healthy lifestyles, including PA.

PA is important, not only for diabetes patients to maintain good control but also for prevention of T2DM. Since the burden of diabetes is increasing, community-based lifestyle intervention may target not only patients, but also people at risk and the general population. Recent evidence advocated the earlier introduction of physical education in schools.[49] Furthermore, providing accessible health education to people before they are diagnosed with diabetes will decrease the burden of diabetes within the Thai community. Physical education and opportunities should be provided in order to start a healthy life-course.

Strengths and Limitation of This Study

This study was the first study to use the IPAQ-SF to evaluate the relationship between T2DM and PA in the community and primary healthcare setting in Thailand. This study was conducted under a detailed plan such as the eligibility criteria, and definition of control.

This study was not without limitations. There is a possibility of recall bias in the nature of a self-administered survey but it is overcome by applying the standard instrument validated to measure PA. This study suggested the impact of the health education and PA promotion for T2DM patients attending Sanpatong District Hospital for treatment and the primary healthcare centers for monthly follow-up within six months. In the nature of a case-control study, the findings of association between exposure and outcome should not be interpreted as causal inference. Results are merely aimed to identify the current situation of the community level diabetes care and prevention for further intervention. Future study may assemble a longitudinal diabetes cohort study to examine the effect of lifestyle changes and different degrees of PA on long-term diabetes outcomes.

Conclusions

Our study found that patients with T2DM in Chiang Mai, Thailand, were more likely to receive more PA education and have higher levels of PA than were those who had not been diagnosed with T2DM. Education in PA from healthcare facilities could lead to the improvement of physical inactivity among patients with T2DM. These findings indicated that the successful and prompt delivery of diabetes health education promoted lifestyle changes in the district level and the primary healthcare setting of Thailand.

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Disclosure

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