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RESEARCH ARTICLE

Comparison of sleep and health behaviors among diabetic patients and non-diabetics in Phitsanulok, Thailand: a cross-sectional study [version 1; peer review: 1 approved, 1 approved with reservations]

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is a global public health problem. To avoid disease complications, diabetic patients have to control their blood glucose and maintain a healthy lifestyle including a healthy diet, weight control, moderate exercise and smoking cessation.

Methods: This study aimed to survey sleep, eating and exercise behaviors of diabetic patients in Bang Rakam district, a rural community in Phitsanulok province, Thailand. The data on sleep and other health behaviors were taken from 1,385 T2DM patients and 1,394 non-T2DM controls, who were aged 30 - 85 years and were free from other chronic diseases. The data were collected using a structured questionnaire.

Results: Compared to the control group, the diabetic group had a significantly higher body mass index (BMI). However, fewer of them were found to smoke cigarettes and drink alcohol. Most of the participants were 'morning people' who slept 7-9 hours per day. It was found that sleep ≥ 8 hours increased the risk of diabetes among women (OR = 1.27, 95% CI 1.03 - 1.56). The diabetic group reported eating chicken and vegetables more than the control group. They also avoided eating beef and eating more than a cup of rice per meal. However, the T2DM group did fewer physical activities, such as walking, biking or playing sports, during their leisure time.

Conclusions: Compared to the control group, diabetic patients in a rural community of Thailand had healthier sleep, lifestyle and eating behaviors but not healthier exercise behaviors, especially among obese women. Diabetic prevention programs should emphasize and

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promote weight control and increasing levels of exercise.

Keywords

Diabetes mellitus, Diabetic care, Health behavior, Sleep duration, Sleep deprivation

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Introduction

Type 2 diabetes mellitus (T2DM) is a global public health problem. It has been estimated that by the year 2030, there will be 439 million people with T2DM (Olokoba *et al.*, 2012). The well-established risk factors for this disease are genetic factors, eating behaviors and exercise (Zheng *et al.*, 2018). Recent studies also related T2DM to sleep and lifestyle. In a large population study in Korea, it was found that ‘evening people’ (those who go to bed late, being alert and prefer to work at night) had an increased diabetic risk (odds ratio, OR = 1.73, 95% CI 1.01-2.95) compared to ‘morning people’ (those who usually go to bed early and like to work or being active during the day) (Yu *et al.*, 2015).

In meta-analysis studies, there a strong U-shaped dose-response association between T2DM and sleep quality and quantity has been observed (Cappuccio *et al.*, 2010; Lee *et al.*, 2017). Compared to men with seven hours of sleep, the risk of T2DM was about twice among for a short sleeper (under or equal to five or six hours of sleep per night) and three times among for a long sleeper (over eight hours) (Heianza *et al.* (2014); Yaggi *et al.*, 2006). reported a similar result among ≤ 45 year-olds but not for those ≥ 60 years of age. In experimental studies, sleep deprivation increased insulin resistance, hunger hormone levels, appetite and food intake but reduced glucose metabolism, leading to obesity, a common predictive factor for diabetes (Beccuti & Pannain, 2011; Reutrakul & Van Cauter, 2018).

On the other hand, T2DM itself can interfere with sleep and cause sleep apnea among diabetic patients (Barone & Menna-Barreto, 2011; Resnick *et al.*, 2003). Poor sleep is often found among T2DM patients as compared to healthy control groups (Trento *et al.*, 2008). A study among elderly Iranian women with T2DM found that being a poor sleeper is associated with: being middle-aged (OR = 2.03, 95% CI 1.01-4.08); having a longer duration of diabetes (OR = 1.77, 95% CI 0.98-3.13); and having high cholesterol levels ≥ 240 mg/dL (OR = 1.99, 95% CI 1.01-3.94) (Shamshirgaran *et al.*, 2017). This was consistent with a previous study, which also reported a higher prevalence of sleep disorders (33.7%) among T2DM patients than in a non-diabetic control group (8.2%) (Sridhar & Madhu, 1994). A study in the United States reported that 55% of T2DM patients have poor sleep (Luyster & Dunbar-Jacob, 2011). Sleep problems among diabetic people might be caused by the disease itself, which affects neurobehavioral and endocrine functions, or due to complications of the disease, such as peripheral neuropathy, restless legs syndrome, polyuria and associated depression (Khandelwal *et al.*, 2017). In an experimental study, sleep restriction (five hours per night) for a week can reduce insulin sensitivity and increase blood glucose; these changes affected kidney function and increased urination, which interfered with sleep (Buxton *et al.*, 2010; Reutrakul & Van Cauter, 2018).

To avoid disease complications, diabetic patients have to control their blood glucose and maintain a healthy lifestyle through, for example, a healthy diet, weight control, moderate exercise and smoking cessation (Stolar, 2010; Tang *et al.*, 2008). Optimal control of sleep duration and quality was also proposed as an intervention to improve blood glucose levels in patients with

T2DM (Trento *et al.*, 2008). However, studies about the health behaviors of diabetic patients is surprisingly rare. A population based survey in Australia reported that there was a minimal change in lifestyle among people after being diagnosed with T2DM. Compared to the healthy control group, the recently diagnosed T2DM group had a minimal weight loss of 1.38 kg (95% CI -1.85 to -0.89), and were more likely to stop smoking (OR of quitting = 2.71, 95% CI 1.59-4.63). However, there was no positive improvement in other lifestyle behaviors such as sitting, walking, moderate to vigorous physical activity (MVPA) and vegetable and fruit consumption (Chong *et al.*, 2017).

This study aimed to survey the sleep, eating and exercise behaviors of diabetic patients in a rural community in Phitsanulok province, Thailand. The predictive factors of sleep and other health behaviors were also investigated. The results will be useful for local diabetic care programs and comparative studies worldwide.

Objectives

1. To explore sleep, eating and exercise behaviors among T2DM and non-T2DM groups.
2. To identify factors that affect sleep and exercise among diabetic patients.
3. To determine the association between diabetes and sleep duration.

Methods

This study is an analytical cross-sectional design with a comparison group.

Study site

This study utilized data from a previous case-control study on diabetes and pesticide exposure (Juntarawijit & Juntarawijit, 2018). The data on health behaviors were collected from February to May 2016 from diabetic patients (T2DM) and a non-T2DM control group living in the rural community of Bang Rakam, a district with 95,098 people (in the year 2018) in Phitsanulok province, Thailand. The district is located in the lower northern part of Thailand, about 400 km from Bangkok.

Study participants

The diabetic patients were those who had come to receive follow-up services at seven health promoting hospitals, which were randomly selected, using random number tables, from all 21 local hospitals in the target area. All diabetic patients who met the inclusion criteria were approached at their home by village health volunteers to take part in the study. In this study, the T2DM group was limited to those aged 30–85 years and free from other chronic diseases, such as heart disease, allergies, chronic pulmonary disease, and cancer. For each diabetic case, one healthy control (non-T2DM) who was free from diabetic disease and met the same inclusion criteria as the case was also approached by the same health volunteer based on the convenience sampling method. The control group were neighbors of the diabetic patients matched for gender and age ($\pm$ five years.).

Study questionnaire

In addition to demographic information, data on sleep duration and other health behaviors were collected using an interviewer-administered questionnaire during a face-to-face interview, which was written in the Thai language (Juntarawijit, 2019b). Before use, the questionnaire was tested for question sequencing and understanding. An interview took place at home of each participant. The participants' self-reported sleep duration was collected using the question "How many hours do you usually sleep per day?". Participants were classified as 'current smoker' if they had smoked 100 cigarettes or more in their lifetime and they currently smoke cigarettes. Those who drank alcohol 2-4 times a week were classified as 'alcohol use'. Data on food consumption, including consumption of meat, sausage, vegetable, fruit, sweets, rice and sweet soft drinks, were also collected using 'yes or no' questions. Information on personal lifestyle (whether they are a morning person or an evening person) was collected using the question "What is the lifestyle that best describes you, morning people or evening people: 'morning people' refer to those who usually go to bed early and like to work or being active during the day; 'evening people' are those who go to bed late, being alert and prefer to work at night?". Participants were also asked to report how frequently they did certain physical activities (walking, biking, playing sports or sweating excessively from exercise or physical activity but not from hot climate or health problems) and watched television during their leisure time using two categories: absent (never, rarely) and present (sometimes, often, almost always). Body mass index (BMI) was calculated by dividing body weight (in kg) by height (in meters squared). The high BMI group was those with BMI ≥ 25.00 . For waist to hip ratio (WHR), a high WHR referred to men with WHR ≥ 0.90 or women with WHR ≥ 0.85 . For waist circumference (WC), a high WC referred to men with WC ≥ 90.0 or women with WC ≥ 80 . All of these measurements were assessed by the health volunteers. Data were collected by 50 village health volunteers who were trained on how to use questionnaires and how to interview study participants.

Statistical analysis

Demographic and health behaviors were analyzed using descriptive statistics and Chi-square test for comparison of categorical data. To identify predictive factors of sleep duration, logistic regression was performed, adjusted for gender, age (continuous), waist to hip ratio (WHR) and lifestyle (evening person vs morning person). The predictive factors of physical activity were also analyzed using ordinal regression, with physical activity categorized as never, rarely, sometimes, often and almost always. All analyses were performed using IBM SPSS statistics (version 19). Confidence intervals of 95% were used to determine significant statistics and all p-values are two two-sided. In this study, listwise or case deletion was used to handling of missing data.

Ethical statement

This study was approved by the Ethics Board of Naresuan University (project number 402/59). Written informed consent for an interview and participation in the study was obtained from each of the subjects before the interview process.

Results

From a dataset of 2,936, 157 (3.4%) were discarded as they were missing important information, such as age (17 cases) and sleep data (140 cases). In total, data from 2,779 participants (1,385 cases and 1,394 controls), with a 92.6% response rate, were included in data analysis.

Most of the participants were female (74.4% for T2DM and 72.8% for non-T2DM) with a comparable mean age between the T2DM (61.1 ± 10.0 years) and non-T2DM groups (60.2 ± 9.8 years) (Table 1) (Juntarawijit, 2019a). However, the T2DM group had significantly higher obesity indices, with an average BMI of 24.9 ± 4.7 vs. 23.8 ± 4.3 (T2DM to non-T2DM group), waist to hip ratio (WHR) of 0.91 ± 0.14 vs. 0.90 ± 0.11 and waist circumference (WC) of 36.8 ± 11.8 vs. 35.6 ± 11.9 . In comparison to the control group, there were more participants

Table 1. General characteristic and health behaviors of type 2 diabetes mellitus (T2DM) and non-T2DM groups.

Characteristic	T2DM n (%)	Non-T2DM n (%)	P-value (χ^2 test)
Demographic information			
Gender (n = 2779)	N = 1394	N = 1385	
Female	1030 (74.4)	1015 (72.8)	0.37
Male	355 (25.6)	379 (27.2)	
Age	N = 1385	N = 1394	0.11
30–40	67 (4.8)	68 (4.9)	
45–54	290 (20.9)	331 (23.7)	
55–64	523 (37.8)	542 (38.9)	
65–74	358 (25.8)	338 (24.2)	
75–85	147 (10.6)	115 (8.2)	
Mean $\pm$ SD	61.1 ± 10.0	60.2 ± 9.8	

Characteristic	T2DM n (%)	Non-T2DM n (%)	P-value (χ^2 test)
Occupation (n = 2684)	N = 1333	N = 1351	0.01*
Retirement	557 (41.8)	427 (31.6)	
Farmer	426 (32.0)	543 (40.2)	
Agriculture employee	203 (15.2)	260 (19.2)	
Personal business/civil servant	147 (11.0)	121 (9.0)	
Obesity indices			
BMI (n = 2675)	N = 1334	N = 1341	<0.01*
≤18.5	75 (5.6)	99 (7.4)	
18.6–22.9	409 (30.7)	538 (40.1)	
23.0–24.9	291 (21.8)	254 (18.9)	
25.0–29.9	396 (29.7)	343 (25.6)	
≥30	163 (12.2)	107 (8.0)	
Mean ± SD	24.9 ± 4.7	23.8 ± 4.3	
WHR (n = 2617)	N = 1301	N = 1316	<0.01*
≤0.80	86 (6.6)	125 (9.5)	
0.81–0.85	110 (8.5)	142 (10.8)	
0.86–0.90	357 (27.4)	384 (29.2)	
0.91–0.95	515 (39.6)	484 (36.8)	
0.96–1.00	182 (14.0)	149 (11.3)	
≥1.10	51 (3.9)	32 (2.4)	
Mean ± SD	0.92 ± 0.14	0.90 ± 0.11	
Waist circumference (WC) (n = 2753)	N = 1372	N = 1381	0.57
<80	1327 (96.7)	1336 (96.7)	
80–90	22 (1.6)	27 (2.0)	
>90	23 (1.7)	18 (1.3)	
Mean ± SD	36.8 ± 11.8	35.6 ± 11.9	
Lifestyle			
Evening or Morning (n = 2743)	N = 1361	N = 1382	0.49
Evening person	94 (6.9)	86 (6.2)	
Morning person	1267 (93.1)	1296 (93.8)	
Smoke a cigarette (n = 2719)	145 (10.8)	196 (14.3)	<0.01*
Alcohol use (n = 2709)	89 (6.6)	131 (9.7)	<0.01*
Food and drink consumption			
Meat type			
Chicken (n = 2175)	174 (16.8)	154 (13.5)	0.03*
Beef (n = 2594)	445 (34.7)	532 (40.6)	<0.01*
Sausage/ball/hotdog (n = 2024)	104 (10.4)	93 (9.1)	0.33
Vegetable (n = 2756)	1254 (91.5)	1233 (89.0)	0.03*
Fruit (n = 2749)	870 (63.6)	852 (61.7)	0.34
Sweet (n = 2754)	558 (40.6)	532 (38.5)	0.26
Rice (n = 2728)	1349 (99.4)	1350 (98.5)	0.23
Eating rice more than a cup per meal (n = 2678)	499 (37.4)	572 (42.6)	<0.01*
Drinking sweet soft drinks (n = 2718)	625 (46.4)	694 (50.7)	0.26

Characteristic	T2DM n (%)	Non-T2DM n (%)	P-value (χ^2 test)
Activities and exercise			
Physically active, compared with people the same age (n = 2642)	N = 1317	N = 1325	<0.01*
Far less	145 (11.0)	95 (7.2)	
Less than	391 (29.7)	265 (20.0)	
About the same	576 (43.7)	649 (49.0)	
More than	172 (13.1)	271 (20.5)	
Far more	33 (2.5)	45 (3.4)	
Sweating** (n = 2643)	N = 1316	N = 1327	0.06
Never	483 (36.7)	532 (40.1)	
Rarely	347 (26.4)	286 (21.6)	
Sometimes	349 (26.5)	370 (27.9)	
Often	114 (8.7)	118 (8.9)	
Almost always	23 (1.7)	21 (1.6)	
Playing sport (n = 2638)	N = 1323	N = 1315	<0.01*
Never	469 (35.4)	413 (31.4)	
Rarely	390 (29.5)	335 (25.5)	
Sometimes	326 (24.6)	390 (29.7)	
Often	122 (9.2)	153 (11.6)	
Almost always	16 (1.2)	24 (1.8)	
Walking (n = 2631)	N = 1312	N = 1319	<0.01*
Never	100 (7.6)	89 (6.7)	
Rarely	292 (22.3)	200 (15.2)	
Sometimes	375 (28.6)	356 (27.0)	
Often	467 (35.6)	570 (43.2)	
Almost always	78 (5.9)	104 (7.9)	
Riding a bicycle (n = 2637)	N = 1314	N = 1323	0.01*
Never	586 (44.6)	423 (32.0)	
Rarely	298 (22.7)	276 (20.9)	
Sometimes	202 (15.4)	270 (20.4)	
Often	189 (14.4)	278 (21.0)	
Almost always	39 (3.0)	76 (5.7)	
Watching television (n = 2622)	N = 1308	N = 1314	0.03*
Never	83 (6.3)	56 (4.3)	
Rarely	230 (17.6)	223 (17.0)	
Sometimes	541 (41.4)	515 (39.2)	
Often	377 (28.8)	442 (33.6)	
Almost always	77 (5.9)	78 (5.9)	

* Significant with $p < 0.05$ (two-sided).

** Sweating refers to an excessive sweat from exercise or physical activity but not from hot climate or health problems.

in the T2DM group who classified themselves as being in retirement or housewives (41.8% vs. 31.6%) and fewer as being a farmer (32.0% vs. 40.2%). A lower percentage of the T2DM group were current cigarette smokers (10.8% vs. 14.3%) and alcohol users (6.6% vs. 9.7%).

Most of the participants (81.9% of T2DM and 82.3% of non-T2DM) slept 7–9 hours per day (Table 2). However, in comparison to control group, there was a significantly higher proportion of diabetics whose sleep hours were ≤ 5 h, and ≥ 8 h

(Table 2). Nearly all of the participants (93.1% for T2DM and 93.8% for non-T2DM) classified themselves to be morning people.

Logistic regression analysis found a significant association between diabetes and a sleeping time of ≥ 8 hours (OR = 1.21, 95% CI 1.02–1.43) after being adjusted for gender and age (Table 3). This association did not change much after being adjusted for WHR (OR = 1.20, 95% CI 1.00–1.43) and lifestyle (OR = 1.20, 95% CI 1.00–1.44).

Table 2. The number of sleeping hours per day among type 2 diabetes mellitus (T2DM) and non-T2DM.

	T2DM n (%)	Non-T2DM n (%)	P-value (χ^2 test)
Sleeping hours (n = 2779)	N = 1385	N = 1394	0.24
2	4 (0.3)	1 (0.1)	
4	5 (0.4)	6 (0.4)	
5	34 (2.5)	27 (1.9)	
6	81 (5.8)	107 (7.7)	
Subtotal	124 (9.0)	141 (10.1)	
7	246 (17.8)	276 (19.8)	
8	574 (41.4)	568 (40.7)	
9	314 (22.7)	304 (21.8)	
Subtotal	1134 (81.9)	1148 (82.3)	
10	106 (7.7)	90 (6.5)	
11	16 (1.2)	9 (0.6)	
12	5 (0.4)	6 (0.4)	
Subtotal	127 (9.3)	105 (7.5)	
Sleep hour group	N=1385	N=1394	0.05*
≤ 5 hours	(3.2)	34 (2.4)	
6–7 hours	327 (23.6)	383 (27.5)	
≥ 8 hours	1015 (73.3)	977 (70.1)	

* Significant with $p < 0.05$ (2-sided).

Stratified analysis found that a sleeping time of ≥ 8 hours was associated with women (OR = 1.27, 95% CI 1.03–1.56) and a high WHR (OR = 1.28, 95% CI 1.04–1.59) (Table 4). A sleeping time of ≤ 5 hours was significantly associated with a high WC (OR = 3.14, 95% CI 1.13–8.75) and women with a high WC (OR = 3.47, 95% CI 1.21–9.97). A short sleep (≤ 5 hours) is also strongly associated with being an evening person (OR = 5.92, 95% CI 3.46–10.13) and being a woman who is an evening person (OR = 7.55, 95% CI 4.17–13.66).

Compared with the control group, there were more participants in the T2DM group who eat chicken (16.8% vs. 13.5%, $p=0.03$) and vegetables (91.5% vs. 89.0%, $p=0.03$) (Table 1). However, the opposite was true for those who eat beef (34.7% vs. 40.6%) and eat more than a cup of rice per meal (37.4% vs. 42.6%, $p<0.01$). For sausage, fruit, desert and rice, the two groups had a similar percentage of consumption.

For exercise and physical activity, participants in the T2DM group were less active than those in the control group. There was a higher percentage of T2DM who classified themselves being 'far less' or 'less than' active during their leisure time (40.7% vs. 27.2%) (Table 1). Moreover, there were fewer of them who reported excessive sweating (36.9% vs. 38.4%) during their free time. The diabetic group also had lower percentage of those who play sports or do exercise (35.0% vs. 43.1%), walking (70.1% vs. 78.1%) and cycling (32.8% vs. 47.1%) during their leisure time.

The behavior of the T2DM that was healthier compared to the control group was in watching television. There was a slightly

Table 3. Association (odds ratio) between sleep hour and diabetes (N = 2779).

	Model 1		Model 2		Model 3	
	≤ 5 hours	≥ 8 hours	≤ 5 hours	≥ 8 hours	≤ 5 hours	≥ 8 hours
Diabetes ^a	1.45 (0.91 - 2.34)	1.21 (1.02 - 1.43)*	1.45 (0.89 - 2.36)	1.20 (1.00 - 1.43)*	1.32 (0.79 - 2.21)	1.20 (1.00 - 1.44)*
Among gender ^b						
Women	-	-	-	-	1.21 (0.68 - 2.16)	1.27 (1.03 - 1.56)*
Men	-	-	-	-	1.84 (0.58 - 5.87)	1.05 (0.74 - 1.49)

^a Model1: adjusted for gender and age (continuous).

Model2: added waist-hip ratio (continuous).

Model3: added lifestyle (evening person, morning person).

^b Adjusted for gender, age, waist-hip ratio and style.

* Significant with $p < 0.05$ (two-sided).

lower percentage of the T2DM group who reported watching television during their leisure time compared to the control group (76.1% vs. 78.7%). Further analysis using ordinal regression found BMI to be associated with walking, riding a bicycle and exercise (Table 5).

Discussion

Health behaviors among diabetic and non-diabetic groups

Most of the participants in this study had a healthy sleep pattern and lifestyle. Over 80% of the participants usually sleep 7–9 hours per day, which is considered to be a healthy amount of sleep (Ip & Mokhlesi, 2007). However, a closer look revealed that there was a higher percentage of the T2DM group compared to the control group who sleep less than six hours per day (3.2% vs. 2.4%) or more than nine hours per day (9.3% vs. 7.5%)

(Table 1) than the control group. Comparing these results to the literature, these participants had a better sleep pattern. The National Sleep Foundation in the United States reported that about 30% of middle-aged men and women slept less than six hours per night (Ip & Mokhlesi, 2007). Another study in the United States reported about half of diabetics had sleep problems (Shamshirgaran *et al.*, 2017).

Further analysis revealed that sleep ≥ 8 hours was significantly associated with being women (OR = 1.27, 95% CI 1.03-1.56) and having a high WHR (OR = 1.28, 95% CI 1.04-1.59). A short sleep duration (≤ 5 hours) was significantly associated with a high WC (OR = 3.14, 95% CI 1.13-8.75) and women with a high WC (OR = 3.47, 95% CI 1.21-9.97) and being an evening person (OR = 5.92, 95% CI 3.46-10.13) and women who are

Table 4. Odds ratio of predictive factors and sleeping duration.

	Short sleep (≤ 5 hours)	Long sleep (≥ 8 hours)
High BMI ^a	1.03 (0.60 - 1.75)	0.99 (0.82 - 1.20)
Women with high BMI ^b	1.16 (0.64 - 2.10)	1.00 (0.81 - 1.25)
Men with high BMI ^b	0.37 (0.08 - 1.76)	0.95 (0.66 - 1.38)
High WHR ^a	1.35 (0.73 - 2.51)	1.28 (1.04 - 1.59)*
Women with high WHR ^b	1.37 (0.66 - 2.83)	1.23 (0.95 - 1.60)
Men with high WHR ^b	1.15 (0.34 - 3.92)	1.43 (0.97 - 2.10)
High WC ^a	3.14 (1.13 - 8.75)*	0.79 (0.48 - 1.29)
Women with high WC ^b	3.47 (1.21 - 9.97)*	0.74 (0.43 - 1.25)
Men with high WC ^b	NA	1.27 (0.26 - 6.08)
Evening person ^a	5.92 (3.46 - 10.13)*	0.43 (0.31 - 0.60)*
Women who are evening people ^b	7.55 (4.17 - 13.66)*	0.40 (0.26 - 0.59)*
Men who are evening people	1.58 (0.33 - 7.71)	0.50 (0.27 - 0.91)*

All tested used 6–7 hours as a reference, with 95% confidence intervals (p-value <0.05).

^a Adjusted for gender, age, waist-hip ratio and lifestyle.

^b Adjusted for age, waist-hip ratio and lifestyle.

NA = data not available.

Table 5. Association between body mass index (BMI) and physical activities during a leisure time among the type 2 diabetes mellitus (T2DM) group.

BMI	Walking	Riding a bicycle	Exercising
≤ 18.5	1.07 (0.64 - 1.78)	0.59 (0.33 - 1.05)	0.86 (0.51 - 1.45)
18.6 - 22.9	1.54 (1.10 - 2.16)*	1.43 (1.01 - 2.02)*	1.30 (0.92 - 1.82)
23.0 - 24.9	1.33 (0.93 - 1.89)	1.75 (1.21 - 2.53)*	1.57 (1.09 - 2.24)*
25.0 - 29.9	1.43 (1.02 - 2.00)*	1.59 (1.12 - 2.26)*	1.66 (1.18 - 2.33)*
≥ 30.0	1.0	1.0	1.0

Note: Data was analyzed using ordinal regression. Physical activity categorized as: never, rarely, sometimes, often, almost always.

* Statistically significant (p <0.05).

evening people (OR = 7.55, 95% CI 4.17-13.66). These results were supported by a study that reported that sleep disturbance increases metabolic disorders and obesity (Chattu *et al.*, 2019).

Compared to the control group, the T2DM group were more overweight and had a higher BMI, (24.9 ± 4.7 vs. 23.8 ± 4.3), higher WHR (0.91 ± 0.14 vs. 0.90 ± 0.11) and higher WC (36.8 ± 11.8 vs. 35.6 ± 11.9) (Table 1). This was not surprising since obesity is a well-established risk factor of diabetes. In an epidemiological study, a short sleep was associated with BMI and weight gain (Leproult & Van Cauter, 2010). In laboratory studies, sleep deprivation affected sympathovagal balance, evening concentrations of cortisol and ghrelin hormones or hunger hormones, but decreased glucose tolerance, insulin sensitivity and leptin, a hormone controlling body weight (Van Cauter & Knutson, 2008). These changes increase blood glucose (Nedeltcheva & Scheer, 2014) and appetite for carbohydrate-rich food (Ip & Mokhlesi, 2007).

Compared with other studies, the number of cigarette smokers (10.8% of T2DM and 14.3% of non-T2DM) and alcohol users (6.6% of T2DM and 9.7% of non-T2DM) in this study were relatively small. In the United States, the prevalence of cigarette smoking among adults with diabetes was about 23.6% (Ford *et al.*, 2004). A study in California, United States, reported that 50% of participants in the diabetic group consumed alcohol (Ahmed *et al.*, 2006).

Compared to the control group, the prevalence of smoking and alcohol consumption among the T2DM group was significantly lower ($p < 0.01$). A recent study in Australia also reported a higher rate of smoking cessation (OR for quitting smoking = 2.71, 95% CI 1.59-4.63) among recently diagnosed T2DM as compared to a healthy control group (Chong *et al.*, 2017). This behavior change was often claimed to be a result of diabetic care programs and global trends of cigarette and alcohol consumption (Shi *et al.*, 2013).

Concerning eating behaviors and choice of food, the diabetic group trended to be healthier than the control group and were more likely to eat foods that are believed to be good for health. Compared to non-T2DM, there was a significantly higher percentage of the T2DM group who reported eating vegetables (91.5% vs. 89.0%, $p = 0.03$) and chicken (16.8% vs. 13.5%; $p = 0.03$) and the opposite was true for beef (34.7% vs. 40.6%, $p < 0.01$) and eating more than a cup of rice per meal (37.4% vs. 42.6%, $p < 0.01$). A similar study in Australia also found a lifestyle change among newly diagnosed diabetic patients (Chong *et al.*, 2017).

However, it must be noted that there were a large portion of participants in both T2DM and non-T2DM groups who reported eating fruit (63.6% vs. 61.7%), sweets (40.6% vs. 38.5%), and drinking sweet soft drinks (46.4% vs. 50.7%). Eating these foods might affect blood sugar and sleep pattern.

Comparing the frequency of several physical activities performed during their leisure time, participants in the T2DM group were less active than the control group. A significantly higher

number of T2DM participants admitted to being less active compared with people of the same age and not doing exercise or playing sports as often as the control group (Table 1). There were also fewer T2DM participants who reported doing walking (41.5% vs. 51.1%) and riding a bicycle (17.4% vs. 26.7%) during their leisure time. These results are supported by other studies. In a study in rural communities of Missouri, Tennessee, and Arkansas, it was reported that 37% of T2DM patients had no leisure-time physical activity (Deshpande *et al.*, 2005). Hays and Clark (1999) also found that over half of T2DM (54.6%) patients, mostly elderly females, had no weekly physical activity. However, a study in Nepal reported that 52% of diabetic patients were moderately active and 28% were highly active (Kadariya & Aro, 2018). This discrepancy in physical activity might be related to the culture and lifestyle of the patients. It was expected that study participants in this study would be more active because they are rural people who mainly work in agriculture.

Further ordinal regression analysis revealed that physical activities were associated with obesity (BMI). Those with a lower BMI trended to have a higher rate of walking, biking and exercising (Table 5). This result is well consistent with literature. A study on outpatients with T2DM and their matched controls found that the total energy expenditure (< 300 kcal/day), number of steps (< 1500 /day), physical activity duration (< 130 min/day) and active energy expenditure/day (< 300 kcal) were all lower in the diabetic group ($p < 0.05$) (Fagour *et al.*, 2013; Hamasaki, 2016). This lower physical activity might be partially due to a fear of joint or leg pain (Dutton *et al.*, 2005) or hypoglycemia (BrazEAU *et al.*, 2008).

Association between diabetes and sleep

After applying several grouping methods, the association was found to be significant only when sleep duration was grouped to ≤ 5 hours, 6–7 hours and ≥ 8 hours. In comparison to the 6–7 hours group, further analysis using logistic regression found that a significant association between diabetes and sleep was only among women with ≥ 8 hours of sleep (OR = 1.27, 95% CI 1.03-1.56) after being adjusted for age, gender, WHR and lifestyle (Table 3). A similar result was also reported in a study in Finland, which found that sleep of ≥ 8 hours increased the risk of diabetes among middle aged women (Tuomilehto *et al.*, 2008). The effect of oversleeping on the risk of developing diabetes is well established, but most of the previous studies use 7-8 hours of sleep as a reference and defined oversleep to be 10–12 hours per day (Chattu *et al.*, 2019). It was also noticed that the relative risk of diabetes in this study (OR = 1.27) was rather low compared with those reported in previous studies, which mostly reported sleep to increase diabetic risk by 2–3 times (Heianza *et al.*, 2014; Yaggi *et al.*, 2006). These results might be explained by the fact that sufficient sleep depends on both quantity and quality of sleep (Chattu *et al.*, 2019). Since most participants in this study are rural villagers with a healthier lifestyle, they were more likely to have a good sleep and thus, require a shorter sleep duration. This was supported by the fact that only approximately 7% of the participants (T2DM and non-T2DM) who classified themselves to be evening people that like to stay up late at night (Table 1).

It was found that less than 7% of the study participants are evening people and the association between diabetes and lifestyle was not statistically significant. These results were in contrast to previous studies. In a large study in Korea, there was a large proportion of people who were evening people, and this group was at risk of diabetes (OR = 1.73, 95% CI 1.01-2.95). (Yu *et al.*, 2015). The differences in workload, lifestyle, social activities and technology might affect sleep patterns of the two groups. Most of the participants in this study were rural villagers, while those in the Korean study were urban people with a modern lifestyle. In Thailand, most villagers usually go to bed early after being exhausted from hard, physical work on the farm during the day and they usually wake up early in the morning to have enough time to prepare food for their family members and the Buddhist monks.

Study limitations

One of the main limitations of this study was that it used a cross-sectional design and there was a lack of data on diabetes onset. Since the relationship between diabetes and sleep is double-sided, it therefore cannot be determined whether sleep causes diabetes or the disease interferes with the sleep pattern of the patient (Chattu *et al.*, 2019). This bias will cause a positive effect and overestimate the association of diabetes and sleep. Without data on diabetic onset, behavior change and disease duration cannot be analyzed. This is also true of the effect of sleep duration on glucose control. These two issues are often reported in literature (Chong *et al.*, 2017).

Conclusion

In conclusion, this study revealed that diabetic patients in a rural community in Thailand had healthy behaviors regarding sleep, lifestyle, eating, cigarette smoking and alcohol consumption. However, they tended to play sports, walk or ride a bicycle during their leisure time less often than the control group with a similar gender and age. This study also found that sleep of ≥ 8 hours increases the risk of diabetes as compared to sleep of 6–7 hours. Sleep was significantly related to gender, lifestyle and obesity. Those with high BMIs tended to have low levels of physical activity during their leisure time. In addition to weight control, diabetic prevention programs should emphasize and promote healthy sleep patterns and exercise, especially among women. More research on different societies and lifestyles are required before the effect of oversleeping on diabetes risk can be clearly understood.

Data availability

Underlying data

Figshare: Sleep and health behaviors among diabetic and non-diabetic groups. [10.6084/m9.figshare.8246780](https://figshare.com/ndownloader/html/10.6084/m9.figshare.8246780) (Juntarawijit, 2019a)

This project contains the following underlying data:

- Diabete-dataset.sav (dataset containing demographic characteristics, medical information and questionnaire responses for all participants)
- Data Dictionary.docx

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).

Extended data

Figshare: Questionnaire-sleep and health behavior among diabetes. [10.6084/m9.figshare.8298689](https://figshare.com/ndownloader/html/10.6084/m9.figshare.8298689) (Juntarawijit, 2019b)

This project contains the following extended data:

- Questionnaire-English.docx
- Questionnaire-Thai.docx

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).

Grant information

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The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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Ahmad Alkhatib

Teesside University, Middlesbrough, UK

This is a very good article, which is needed to demonstrate the exercise and nutritional prevention of diabetes by understanding those behaviours in a group of individuals with or without diabetes in Thailand.

The article is well written in many parts. However, its significance is not clear in the way it has been written, so I suggest a major revision to incorporate some amendments in order to be accepted for indexing. Once done, I am happy to look over it again.

Generic:

- Please check the English and grammar throughout.

Specific:

Abstract:

- "Diabetic prevention programmes", should be "diabetes prevention programs".
- Terminology use "people with diabetes" rather than "diabetic".

Introduction:

- Expand a little on eating behaviour and diabetes and try make a link on why/why not such factors may be important for communities with a similar lifestyle to those tested here.
- Expand a little with statements showing some mechanisms linking the sleep/eating/exercise habits with the physiology of diabetes and its development.
- Add a paragraph to justify why and what is special about why the rural communities in Thailand have been tested here. The reader needs to understand the link between these.
- The last paragraph needs to have a statement about what is not known and how this study

is adding to such knowledge.

Methods:

- Questionnaire: Specify what type of interview in the 1st paragraph.
- Sleep questions, is there a valid sleep questionnaire used here? Why only one question? How do you differentiate between deep sleep/etc.? Did the interview cover more than the one question asked? Details are needed.
- Data on food consumption requires justification, what type of questionnaire has been used or developed for this purpose? Why was there a focus on selected foods?
- Frequency of certain physical activities. What physical activity questionnaire was used? Was it IPAQ recall? Any validated questionnaire or justification of the questions selected?

Results:

- It is not clear why Table 3 has many gaps. Is it to do with insufficient number?

Discussion:

- Please add a paragraph to start with, which should clearly state the most important findings and discuss what is novel.
- Many paragraphs seem to repeat what is in the results. All paragraphs should have concluding statements stating what is new and how it is relevant for the field.

Conclusion:

- Avoid repetitions “in conclusion” or “this study reveals”. It needs to go straight to the point and concise.
- Again: the conclusion seems to repeat the findings. Please state the significance of your findings rather than repeating them.
- The findings here contrast with the common perception that people with diabetes have bad lifestyle patterns, instead it showed that a healthy lifestyle pattern based on dietary patterns alone may not be sufficient and that lifestyle prevention of diabetes (esp. T2D) should always include physical activity as an integral part.
- The authors could also make specific suggestions for how to implement physical activity in the rural community they tested based on the finding that some have better physical activity than others.
- A conclusion about the sleep patterns finding is missing and should be added.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Lifestyle prevention of disease

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 05 Dec 2021

Chudchawal Juntarawijit

Responses to the reviewer:

Comment:

This a very good article, which is needed to demonstrate the exercise and nutritional prevention of diabetes by understanding those behaviours in a group of individuals with or without diabetes in Thailand.

The article is well written in many parts. However, its significance is not clear in the way it has been written, so I suggest a major revision to incorporate some amendments in order to be accepted for indexing. Once done, I am happy to look over it again.

Generic:

Please check the English and grammar throughout.

Response:

Thank you very much for reviewing this manuscript and providing valuable and encouraging feedbacks.

The English and grammar was edited by Mr. Kenje Baris Gunda.

Specific:

Abstract:

Comment:

"Diabetic prevention programmes", should be "diabetes prevention programs".

Terminology use "people with diabetes" rather than "diabetic".

Response:

The errors about the terminology use have been corrected.

Introduction:

Comment:

Expand a little on eating behaviour and diabetes and try make a link on why/why not such factors may be important for communities with a similar lifestyle to those tested here.

Response:

More information on eating behaviors and diabetes have been added as suggested.

Comment:

Expand a little with statements showing some mechanisms linking the sleep/eating/exercise habits with the physiology of diabetes and its development.

Response:

A statement on the mechanism linking eating, exercise and diabetes has been added. For sleep and diabetes, it was reported that sleep deprivation increases insulin resistance and indirectly affect diabetes by increasing appetite and body weight. This information has already been presented in the second paragraph.

Comment:

Add a paragraph to justify why and what is special about why the rural communities in Thailand have been tested here. The reader needs to understand the link between these.

Response:

Actually, there were no special characteristics, the community was selected because it has a high number of people with diabetes, and it was in a convenient location.

Comment:

The last paragraph needs to have a statement about what is not known and how this study is adding to such knowledge.

Response:

Introduction has been revised as suggested (see the manuscript).

In the last paragraph, a statement about what is not known has been added.

Methods:

Comment:

Questionnaire: Specify what type of interview in the 1st paragraph.

Response:

Information on the types of interviews are specified in the first paragraph.

Comment:

Sleep questions, is there a valid sleep questionnaire used here? Why only one question? How do you differentiate between deep sleep/etc.? Did the interview cover more than the one question asked? Details are needed.

Response:

Yes, we only asked the participants how long they usually slept each day. For information regarding quality of sleep, we believed that it was rather subjective and hard to justify, therefore, it was not included in the survey. The questionnaire method has been widely used to collect information on sleep duration (Yaggi, Araujo, and McKinlay, 2006) Chong et al., 2017) (Yu et al., 2015).

However, we accept that this will be another important limitation of the study and the issue has been further discussed in study limitations.

Comment:

Data on food consumption requires justification, what type of questionnaire has been used or developed for this purpose? Why was there a focus on selected foods?

The questionnaire was used in previous studies

Response:

In this study, a modified Food Frequency Questionnaire (FFQ) was used. The questionnaire was validated and used in previous studies, e.g. Barrat et al. (2012). Due to different cultures and eating habits, only foods found to relate to diabetes and those often found in Thailand were selected. This information has been added to the method section.

Comment:

Frequency of certain physical activities. What physical activity questionnaire was used? Was it IPAQ recall? Any validated questionnaire or justification of the questions selected?

Response:

In this study, a modified Baecke Habitual Physical Activity Questionnaire (BHPAQ) was used and the questionnaire has been validated in previous studies (Florindo and Latorre, 2003). Yes, the questionnaire method might cause recall bias. However, if the problem occurs, it should equally affect both the study and comparison group and thus, not seriously affect the results.

The issue has been added in study limitations.

Results:

Comment:

It is not clear why Table 3 has many gaps. Is it to do with insufficient number?

Response:

In the first row of the table, the association (ORs) between sleep hours and diabetes in different models were presented. The association was then further analyzed using only data from model 3 (adjusted for all potential confounding factors) in regard to gender, by carrying out a comparison between males and females.

Discussion:

Comment:

Please add a paragraph to start with, which should clearly state the most important findings and discuss what is novel.

Response:

A new paragraph which states the most important findings, has been added to the discussion section as suggested.

Comment:

Many paragraphs seem to repeat what is in the results. All paragraphs should have concluding statements stating what is new and how it is relevant for the field.

Response:

Every paragraph has been reviewed to make sure they do not repeat the results and now contain conclusions of statements.

Conclusion:**Comment:**

Avoid repetitions "in conclusion" or "this study reveals". It needs to go straight to the point and concise.

Response:

The repetition terms have been deleted.

Comment:

Again: the conclusion seems to repeat the findings. Please state the significance of your findings rather than repeating them.

Response:

The conclusion statement has been completely revised.

Comment:

The findings here contrast with the common perception that people with diabetes have bad lifestyle patterns, instead it showed that a healthy lifestyle pattern based on dietary patterns alone may not be sufficient and that lifestyle prevention of diabetes (esp. T2D) should always include physical activity as an integral part.

Response:

Thank you for helping us to clarify this important point. The idea has been added to manuscript.

Comment:

The authors could also make specific suggestions for how to implement physical activity in the rural community they tested based on the finding that some have better physical activity than others.

Response:

In this study, we found that women with high BMIs did the least physical activities and exercise, therefore, we recommend that exercise programs are designed for this specific group.

Comment:

A conclusion about the sleep patterns finding is missing and should be added.

Response:

A conclusion statement regarding sleep patterns has been added.

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Competing Interests: No competing interests were disclosed.

Author Response 25 Oct 2022

Chudchawal Juntarawijit

Comments

This is a very good article, which is needed to demonstrate the exercise and nutritional prevention of diabetes by understanding those behaviours in a group of individuals with or without diabetes in Thailand.

Response:

Thank you very much for your time and effort in reviewing the manuscript and providing valuable suggestions to improve the paper. All the comments are accepted, and we have tried to revise the paper as such.

Generic:

Comment:

Please check the English and grammar throughout.

Response:

English has been rechecked by Mr. Kevin Mark Roebel, a native English speaker.

Specific:

Abstract:

Comment:

“Diabetic prevention programmes”, should be “diabetes prevention programs”.

Response:

The terminology has been revised as suggested.

Comment:

Terminology use "people with diabetes" rather than "diabetic".

Response:

The terminology "diabetic" has been replaced by "people with diabetes".

Introduction:**Comment:**

Expand a little on eating behaviour and diabetes and try make a link on why/why not such factors may be important for communities with a similar lifestyle to those tested here.

Response:

More information on eating and diabetes has been added. Food choice depends not only on behaviour but also socio-economic status.

Comment:

Expand a little with statements showing some mechanisms linking the sleep/eating/exercise habits with the physiology of diabetes and its development.

Response:

More information on the association between sleep, eating, and exercise has been added as suggested.

Comment:

Add a paragraph to justify why and what is special about why the rural communities in Thailand have been tested here. The reader needs to understand the link between these.

Response:

The information has been added. Information concerning diabetes in Thailand, especially those in small communities, is limited. The selected community may not have special characteristics but has sufficient diabetes cases and convenience for data collection. It can represent a rural community of the province.

Comment:

The last paragraph needs to have a statement about what is not known and how this study is adding to such knowledge.

Response:

Yes, we totally agree. What is not known is the health behaviours, sleep, and other aspects of the lifestyle of people with diabetes in Thailand. In this, we try to study those factors and among various groups. This information was presented in the study objective.

Methods**Comment:**

Questionnaire: Specify what type of interview in the 1st paragraph.

Response:

The information on the type of interview has been added as suggested.

Comment:

Sleep questions, is there a valid sleep questionnaire used here? Why only one question? How do you differentiate between deep sleep/etc.? Did the interview cover more than the one question asked? Details are needed.

Response:

In this study, only duration of sleep and lifestyle (moringness or eveningness) was selected as target information. For sleep quality, we believe it was rather subjective and hard to collect data. We accepted that this was a study limitation and clearly mentioned in the study limitation section.

Comment:

Data on food consumption requires justification, what type of questionnaire has been used or developed for this purpose? Why was there a focus on selected foods?

Response:

In this study, data on food consumption were collected using a modified Food Frequency Questionnaire (FFQ). The questionnaire was tested against a 7-day diet record and found to have high repeatability and good validity score (repeatability for intake was 0.62-0.90 (median 0.81), relative validity was 0.36-0.80 (0.64).

Yes, we focused on only types of foods found to be related to diabetes and those often found in Thailand. This information was already presented in the study questionnaire section.

Comment:

Frequency of certain physical activities. What physical activity questionnaire was used? Was it IPAQ recall? Any validated questionnaire or justification of the questions selected?

Response:

In this study, we used a Baecke Habitual Physical Activity Questionnaire (BHPAQ) which has been adopted by several countries as a reliable tool to measure habitual physical activity in adult men.

Results:

Comment:

It is not clear why Table 3 has many gaps. Is it to do with insufficient number?

Response:

Table 3 presented results OR of different models. Further analysis was conducted among men and women. However, this analysis was done only on model3, the best model which included all related variables. This left data on Model 1 and Model2 blank.

Discussion:

Comment:

Please add a paragraph to start with, which should clearly state the most important findings and discuss what is novel.

Response:

In this study, the most important issues were health behaviours of T2DM. Thus, we began with this finding.

Comment:

Many paragraphs seem to repeat what is in the results. All paragraphs should have concluding statements stating what is new and how it is relevant for the field.

Response:

In each paragraph, we have summarized the most important finding before discussing it.

Conclusion:

Comment:

Avoid repetitions “in conclusion” or “this study reveals”. It needs to go straight to the point and concise.

Response:

Thanks for the reminder. We try to avoid those wordy statements.

Comment:

Again: the conclusion seems to repeat the findings. Please state the significance of your findings rather than repeating them.

Response:

The concluding statement has been revised and those repetitions were deleted.

Comment:

The findings here contrast with the common perception that people with diabetes have bad lifestyle patterns, instead it showed that a healthy lifestyle pattern based on dietary patterns alone may not be sufficient and that lifestyle prevention of diabetes (esp. T2D) should always include physical activity as an integral part.

Response:

Yes, we agree and thank you for your affirmative.

Comment:

The authors could also make specific suggestions for how to implement physical activity in the rural community they tested based on the finding that some have better physical activity than others.

Response:

Thank you for your suggestion. We recommend those activities with low impact, e.g. walking, swimming, biking or doing yoga. This information has been added. Designing a good physical plan is not easy and many of them often fail within a short period of time. A good physical program should be based on research from the specific group and getting the public involved at an early stage.

Comment:

A conclusion about the sleep patterns finding is missing and should be added.

Response:

The concluding statement has been added as suggested.

Competing Interests: No competing interests were disclosed.

Reviewer Report 11 May 2020

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Anastasia Thanopoulou

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The article compares cross-sectionally sleep and health behaviors among diabetic patients and non-diabetics in a single area in Thailand. The subject is of importance, since Type 2 diabetes mellitus (T2DM) prevention and treatment lie a lot on lifestyle habits. It is well conducted and written. The results show that exercise behaviors should be ameliorated in the diabetic patients' population.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

No source data required

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Diabetes Mellitus, Nutrition, Diabetes Comorbidities

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

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