Original Article

Leisure-time physical activity and milk intake synergistically reduce the risk of pathoglycemia: A cross-sectional study in adults in Beijing, China

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Background and Objectives: To evaluate the synergistic and individual associations of leisure-time physical activity (LTPA) intensity and the frequency of milk intake in adulthood with newly diagnosed pathoglycemia. Pathoglycemia comprised impaired fasting glucose (IFG) and type 2 diabetes mellitus (T2DM). **Methods and Study Design:** This cross-sectional study of 3977 adults was conducted in Mentougou District, Beijing, China. After excluding ineligible individuals or those with missing data, 2977 participants were included in the final analysis. Data on LTPA, milk intake, and other demographic characteristics were obtained through previously designed questionnaires. Newly diagnosed pathoglycemia was determined based on fasting plasma glucose (FPG) concentration. **Results:** Among all participants, 21.4% had newly diagnosed pathoglycemia, 9.9% engaged in moderate to vigorous leisure-time physical activity (MVLTPA), and 63.7% drank milk more than once weekly. Relative to those who engaged in low-intensity LTPA and drank milk less than once weekly, those who engaged in MVLTPA (OR: 0.584, 95%CI: 0.410-0.810) and drank milk more than once weekly (OR: 0.734, 95% CI: 0.614-0.878) had a lower risk of pathoglycemia; this association was greater when both variables interacted (OR: 0.446, 95% CI: 0.287-0.669). **Conclusions:** MVLTPA and enough frequency of milk intake synergistically decreased the risk of pathoglycemia. A future interventional study including both factors should be performed.

Key Words: synergistic associations, leisure-time physical activity, the frequency of milk intake, pathoglycemia, impaired fasting glucose

INTRODUCTION

Diabetes mellitus (DM) has become a global public health problem. In 2017, globally, 451 million people were living with DM, and the cost of DM reached $727,000 million annually.[1] And in 2017 in China, 114 million people had DM, with a prevalence of 10.9%. It has been estimated that in 2045 in China, 119 million people will develop DM, with a prevalence of 11.6%.[1] Type 2 diabetes mellitus (T2DM) accounts for 85%–95% of all cases of diabetes.[1] Furthermore, studies have demonstrated that most individuals with impaired fasting glucose (IFG) may develop T2DM eventually.[2] Recent studies have also revealed that psychological pressure and several aspects of personal behavior, such as physical activity (PA) and diet, are associated with a rapid increase in the prevalence of IFG and T2DM.[3-5] Previous research has focused on the influence of total energy consumption to improve health. However, recent studies have focused more on leisure-time physical activity (LTPA), because among the types of PA, LTPA contributes the most to improving health.[6,7] Recent evidence has indicated that moderate to vigorous leisure-time physical activity (MVLTPA) and milk intake are associated with a decreased prevalence of IFG and T2DM.[3,8,9] Therefore, the synergistic associations of LTPA and milk intake with IFG and T2DM must be examined. Several studies have examined the individual associations of either MVLTPA or dietary factors with IFG and T2DM independently, and very few of them have analyzed the synergistic associations of MVLTPA and milk intake with IFG and T2DM. Therefore, in this study, we assessed the synergistic and the individual effects of MVLTPA and milk intake on IFG and T2DM.

METHODS

Ethical consideration

This study was approved by the Peking University Biomedical Ethics Committee. The approval conforms to the provisions of the 1995 Declaration of Helsinki in (revised in Edinburgh in 2000), and the approval number is

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IRB00001052. Survey respondents provided their written informed consent prior to the conduct of the survey.

Study population

This cross-sectional study was conducted in Mentougou District in Beijing, China, based on the survey Adult Chronic Diseases and Prevalence Factors Monitoring in Mentougou District from October 2016 to November 2016. People in 9 towns and 4 streets were sampled. Those aged ≥18 years who had lived in their locale for 6 months or more in the past year were potential participants. Stratified multistage probability proportional to size sampling was performed in this study. In the first stage, people in administrative villages and neighborhood committees were randomly sampled. In the second stage, those in natural villages or residents' groups of each administrative village or neighborhood committees were randomly sampled. In the third stage, to determine which person will be a potential respondent among their family members, each household was selected through stratified random sampling.

In this study, we excluded people with missing data, specifically data on fasting plasma glucose (FPG) concentrations, the frequency of milk intake, LTPA, and other important covariates, such as gender, age, marital status, education, personal annual income, occupation, BMI (body mass index), smoking status, drinking status, and the consumption of cereals, tubers, vegetables, and fruit daily. Among the 3977 initially recruited, we excluded 311 people who were self-reported to have been diagnosed as having DM by a doctor in a community hospital or above, because the diagnosis of DM could lead to behavioral and psychological changes. Finally, 689 people were excluded because the requisite set of questionnaires, physical examinations, and laboratory measurements had not been completed. The remaining 2977 participants who were eligible and had complete data were included in this study (Figure 1).

This study was a cross-sectional survey in respondents aged ≥18 years. The formula for calculating the minimum sample size was as follows: N=($z_\alpha^{2*}p$*(1-p))/d^2. For our study, p = 35.7% (this was the estimated prevalence of pathoglycemia according to a nationally representative cross-sectional survey in 2013 in mainland China),[10] confidence level (bilateral) $\alpha = 0.05$, d (the allowable error) = $0.1 \times p$, design effect = 1.5, and nonresponse rate = 10%. With these parameters, the minimum sample size was estimated as 1154, and our included study population of 2977 satisfy the demand of the minimum sample size.

Data collection

In this study, face-to-face interviews, laboratory measurements, and physical examinations were performed locally by trained surveyors. The questionnaires previously designed were used to obtain basic respondent information, including information on their demographic characteristics, personal behavior, dietary consumption, and history of DM. Demographic characteristics included gender, age, marital status, education, personal annual income, occupation, aspects of personal behavior-including BMI, smoking status, drinking status and the consumption of cereals, tubers, vegetables, and fruit.

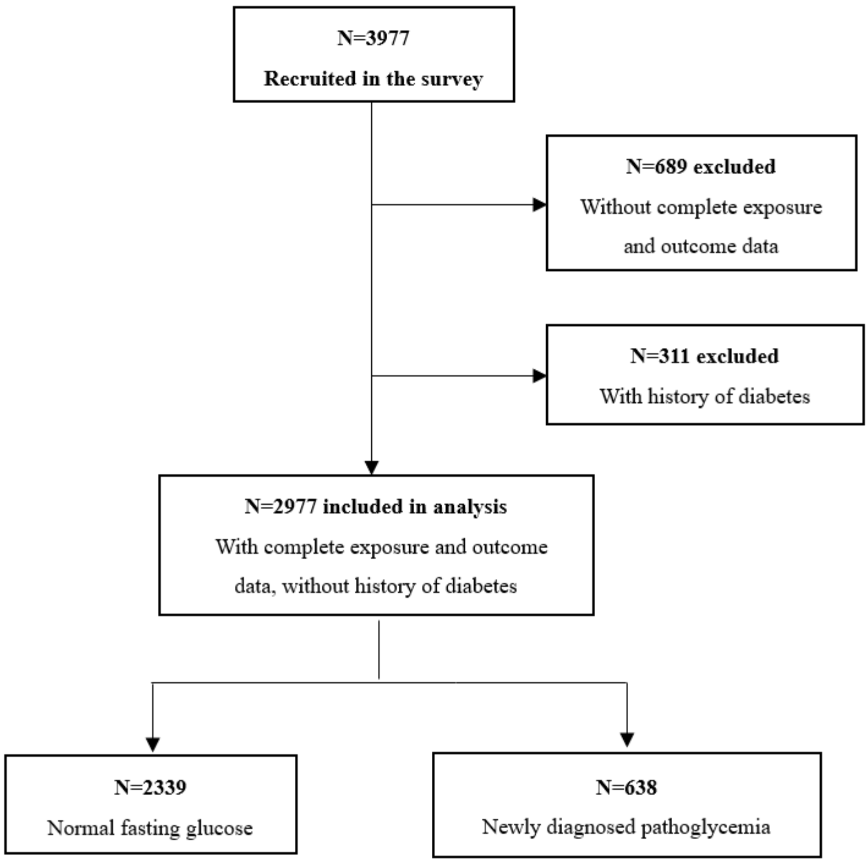

Figure 1. Study design figure.

LTPA intensity was measured using the long volume of International Physical Activity Questionnaire (IPAQ), an effective and widely used questionnaire for examining the PA intensity in adults. Dietary consumption was measured using the food frequency questionnaire (FFQ), which identified the frequency of food (never, monthly, weekly, daily) and the quality each time during the past month. In our research, milk was defined as liquid milk. The frequency of milk intake was determined using FFQ. Although there may be certain differences between the information of milk intake over the past month and the actual situation, the trends are mostly consistent. Furthermore, the recall bias of FFQ in our study was less than that of a survey on milk consumption over the past year. Data on history of DM were obtained from answers to the question "Have you ever been diagnosed as having DM by a doctor in a community hospital or above?"

Physical examinations and laboratory measurements were conducted to obtain data on physiological indexes. Weights and heights were measured with participants wearing light clothing and no shoes. FPG concentrations were measured by trained surveyors from 7 am to 9 pm using professional-grade glucometers provided locally. Participants were required to fast for 8–12 h and abstain from both exercise and hypoglycemic drugs before the measurements of their FPG concentrations.

Definition and groups

In this study, newly diagnosed IFG and T2DM were determined by examining FPG concentration. Specifically, newly diagnosed T2DM was defined as FPG concentration ≥7.0 mmol/L and was not diagnosed as having DM by a doctor in a community hospital or above before by self-reports, and newly diagnosed IFG was defined as FPG concentration ≥6.1 mmol/L and <7.0 mmol/L and was not diagnosed by a doctor in a community hospital or above before by self-reports.[11] However, because these new diagnoses were based only on FPG concentrations in the absence of an oral glucose tolerance test, T2DM may be misdiagnosed as FPG in some patients. Thus, we grouped these cases of newly diagnosed IFG and T2DM into a joint category of newly diagnosed pathoglycemia. Thus, newly diagnosed pathoglycemia was defined as FPG concentration ≥6.1 mmol/L and was not diagnosed by a doctor in a community hospital or above before by self-reports.

In this study, LTPA intensity was classified according to the IPAQ criteria,[12] that is, LTPA intensity was divided into 3 intensities of low, moderate, and vigorous. Some researchers have shown that moderate or vigorous LTPA was potentially associated with a decreased risk of chronic diseases. For example, in a landmark study in a large cohort of people of Chinese ancestry, MVLTPA was determined to reduce the risk of diabetes-related outcomes.[13] Furthermore, in a study in large cohorts of people with cardiometabolic multimorbidity from the United Kingdom, moderate LTPA for 150 min was associated with a longer life expectancy.[14] In addition, according to the guidelines on physical activity for adults in China,[15] blood glucose is potentially reduced by moderate LTPA for more than 150 min weekly or vigorous LTPA for more than 75 min weekly-both were collectively defined as MVLTPA in this study, and LTPA that was less intense than MVLTPA was defined as low-intensity leisure-time physical activity (LILTPA).

The correlation between the frequency of milk and the development of chronic diseases has been investigated,[16] where the frequency of milk intake was measured using FFQ. To ensure the uniformity of units of frequency, our study adopted the unit that is the number weekly of milk consumption.

Socioeconomic status was indicated by education and personal annual income, which is a comprehensive index that has been used in previous research.[17] Education was categorized into 2 levels: middle school education or below was coded as 0, and high school education or above was coded as 1. Personal annual income was also categorized into 2 levels: incomes <RMB30000 and ≥RMB30000 were coded as 0 and 1, respectively. Socioeconomic status was then determined by adding both education and income scores and was segmented into 3 levels (low, middle, and high). BMI was calculated as the weight (kg) divided by square of height (m^2). Based on the physiological characteristics and dietary habits of Chinese people, BMI thresholds suitable for the Chinese population were determined in 2004.[18] Specifically, a normal BMI is 18.5–23.9 kg/m^2; a BMI value above this range indicates overweight or obesity; and we adopted this definition for overweight and obesity. The threshold for the consumption of cereals, tubers, vegetables, and fruit daily was determined by the mean quality of intake of them daily.

Statistical analysis

Binary logistic regression was used to estimate the synergistic and individual effects of LTPA intensity and the frequency of milk intake on newly diagnosed pathoglycemia. The regression model included LTPA intensity × frequency of weekly milk intake as a variable for estimating the synergistic effects, with the group with both LILTPA and a frequency of weekly milk intake ≤1 as the reference group; 95% confidence intervals (CI) were calculated for the associations.

Binary logistic regression was conducted with an unadjusted model and 2 adjusted models. In the unadjusted model, we did not adjust for potential confounders; in the 2 adjusted models, we adjusted for potential confounders. Model 1 was adjusted for gender (male or female), age (<50 or ≥50 years), marital status (married or living with others, single or living apart, or divorced or widowed), socioeconomic status (low, middle, or high), and occupation (manual worker or service staff, manager or technician, unemployed or retired, or others). Model 2 was adjusted for BMI (<24 kg/m^2 or ≥24 kg/m^2), smoking status (less or more than once a daily), drinking status (less or more than once monthly), and the consumption of intake of cereals, tubers, vegetables, and fruit daily based on Model 1.

In accordance with the STROBE guideline,[19] a sensitivity analysis for the stratification of newly diagnosed IFG and newly diagnosed T2DM was conducted in each regression model, and checked for differences in the results between them and newly diagnosed pathoglycemia.

In this study, statistical significance was indicated by

$p<0.05$ (two-tailed). Microsoft Excel 2016 was used for data entry and verification, SPSS (version 25.0) was used for statistical analysis, and Microsoft Excel 2019 was used to draw the figure of synergistic associations of LTPA intensity and the frequency of milk intake with pathoglycemia.

RESULTS

Participant characteristics

In this study, 2977 participants had an average age of 49.22±14.21 years; 44.3% and 55.7% were men and women, respectively. The average ages for male and female participants were 47.61±14.59 and 50.51±13.78 years, respectively.

Among all participants, 78.6% (2339) were healthy, with the remaining 21.4% (638) having newly diagnosed pathoglycemia. In particular, 12.2% (364) had IFG, and 9.2% (274) had T2DM.

Of the 2977 participants, 9.9% (294) and 90.1% (2683) were engaged in MVLTPA and LILTPA, respectively. The frequency of weekly milk intake = 1 was in the low tertile; 36.3% (1080) of the total participants drank milk at a frequency less than or equal to once weekly, and 63.7% (1897) of the total participants drank milk more than once weekly. Table 1 presents the general characteristics of the participants.

Associations of LTPA intensity and the frequency of milk intake with pathoglycemia

In this study, 14.3% and 22.2% of participants who engaged in MVLTPA and LILTPA had newly diagnosed pathoglycemia, respectively (χ^2=9.43, p=0.002). Relative to those with a lower frequency, participants with the frequency of weekly milk intake >1 had a lower prevalence of newly diagnosed pathoglycemia (χ^2=11.2, p=0.001).The results of logistic regression shows, in the unadjusted models, relative to those who engaged in LILTPA and drank milk at a lower frequency, participants who engaged in MVLTPA and drank milk more than once weekly had a significantly decreased prevalence of newly diagnosed pathoglycemia (OR: 0.584, 95% CI: 0.410-0.810; OR: 0.734, 95% CI: 0.614-0.878). After sociodemographic characteristics were adjusted for (Model 1), including gender, age, marital status, socioeconomic status and occupation, the significant association between pathoglycemia and LTPA intensity was still significant (OR: 0.663, 95% CI: 0.461-0.934). After full adjustment (Model 2), engagement in MVLTPA was still associated with a decreased prevalence of pathoglycemia (OR: 0681, 95% CI: 0.473-0.960). The results are detailed in Table 2.

Synergistic associations of LTPA intensity and the frequency of milk intake with newly diagnosed pathoglycemia

In all models, LTPA intensity and the frequency of milk intake had significant synergistic associations with newly diagnosed pathoglycemia. Relative to those who engaged in LILTPA and drank milk at a lower frequency, those who engaged in MVLTPA and had a frequency of weekly milk intake >1 had a significantly lower prevalence of newly diagnosed pathoglycemia. Table 3 details the results of synergistic associations in the unadjusted and 2 adjusted models. Specifically, after adjusting for potential confounders, relative to those who engaged in LILTPA and drank milk at a lower frequency, participants who engaged in MVLTPA and drank milk more than once weekly were 63.1% less likely to develop newly diagnosed pathoglycemia (OR: 0.631; 95% CI: 0.403-0.982). The results of trends and statistical significance of synergistic associations after full adjustment are shown in Figure 2.

Sensitivity analysis

Sensitivity analysis for the stratification of IFG and T2DM indicated that the synergistic and individual associations of LTPA intensity and the frequency of milk intake with IFG or T2DM showed the same trends as those of pathoglycemia. However, no significant results were obtained in several adjusted models. This may be attributable to the small numbers of participants having newly diagnosed IFG and T2DM, which decreases the statistical power of the analysis. The results of sensitivity analysis are presented in Supplementary Material 1.

DISCUSSION

This study has 2 main findings. First, LTPA intensity and the frequency of milk intake were significantly associated with a lower risk of pathoglycemia. This significant association was still present after adjusting for potential confounders, including gender, age, marital status, socioeconomic status, occupation, BMI, smoking status, drinking status, and the consumption of cereals, tubers, vegetables, and fruit daily. Second, LTPA intensity and the frequency of milk intake were synergistically associated with the prevalence of newly diagnosed pathoglycemia, consistent with the findings of the previous studies[8,20-22] as well as with public health recommendations.[23]

Many studies have explored the factors affecting newly diagnosed pathoglycemia, such as PA and diet-related factors. However, because the effective relief of pathoglycemia requires overall behavioral changes, most recent interventions have focused on changing multiple aspects, rather than a single aspect of behavior.[24] Furthermore, consistent with our results, several randomized controlled trials have demonstrated that the combination of PA and dietary factors potentially reduces the prevalence of pathoglycemia.[24-26]

Previous reviews have noted the association of PA with a reduction in HBA1c; this decrease in HBA1c can reduce the risk of pathoglycemia, but only when combined with diet-related factors.[27,28] Furthermore, recent studies have partially uncovered the biological mechanism of milk intake to pathoglycemia. Some components of milk, such as calcium, protein, vitamin, and phosphorus, may benefit to decrease the risk of pathoglycemia. This benefit is partially attributable to significant improvements in vivo insulin sensitivity, FPG concentration, and insulin response from drinking milk more frequently.[8] However, the fat content of milk may affect the prevalence of pathoglycemia. Specifically, low-fat and high-fat milk potentially lower and increase the risk of pathoglycemia, respectively.

The major strength of our study is the analysis of syn-

Table 1. General characteristics of LTPA intensity and the frequency of milk intake in the study population (n/%)

Item	N	LTPA intensity				The frequency of milk intake			
		MVLTPA	LILTPA	χ^2	$p^{\dagger}$	>once/week	≤once/week	χ^2	$p^{\dagger}$
Gender				12.1	<0.001			53.8	<0.001
male	1320	159 (12.0%)	1161 (88.0%)			745 (56.4%)	575 (43.6%)		
female	1657	263 (15.0%)	1493 (85.0%)			1152 (69.5%)	505 (30.5%)		
Age (years)				15.0	<0.001			0.3	0.571
<50	1458	176 (12.1%)	1282 (87.9%)			937 (64.3%)	521 (35.7%)		
≥50	1519	118 (7.8%)	1401 (92.2%)			960 (63.2%)	559 (36.8%)		
Marital status				80.4	<0.001			7.1	0.029
married or living with others	2570	214 (8.3%)	2356 (91.7%)			1618 (63.0%)	952 (37.0%)		
single or living apart	255	66 (25.9%)	189 (74.1%)			182 (71.4%)	73 (28.6%)		
divorced or widowed	152	14 (9.2%)	138 (90.8%)			97 (63.8%)	55 (36.2%)		
Socioeconomic status				21.2	<0.001			63.0	<0.001
low	1017	65 (6.4%)	952 (93.6%)			566 (55.7%)	451 (44.3%)		
middle	791	90 (11.4%)	701 (88.6%)			491 (62.1%)	300 (37.9%)		
high	1169	139 (11.9%)	1030 (88.1%)			840 (71.9%)	329 (28.1%)		
Occupation				60.6	<0.001			28.4	<0.001
manual worker or service staff	809	53 (6.6%)	756 (93.4%)			471 (58.2%)	338 (41.8%)		
managers or technician	881	86 (9.8%)	795 (90.2%)			620 (70.4%)	261 (29.6%)		
unemployment or retired	921	79 (8.6%)	842 (91.4%)			581 (63.1%)	340 (36.9%)		
others	366	76 (20.8%)	290 (79.2%)			225 (61.5%)	141 (38.5%)		
BMI (kg/m^2)				4.6	0.032			17.5	<0.001
<24	1135	129 (11.4%)	1006 (88.6%)			777 (68.5%)	358 (31.5%)		
≥24	1842	165 (9.0%)	1677 (91.0%)			1120 (60.8%)	722 (66.9%)		
Smoking (times/day)				0.1	0.883			94.4	<0.001
<1	2213	217 (9.8%)	1996 (90.2%)			1522 (68.8%)	691 (31.2%)		
≥1	764	77 (10.1%)	687 (89.9%)			375 (49.1%)	389 (50.9%)		
Alcohol (times/ day)				0.8	0.377			69.1	<0.001
<1	2085	213 (10.2%)	1872 (89.8%)			1429 (68.5%)	656 (31.5%)		
≥1	892	81 (9.1%)	811 (90.9%)			468 (52.5%)	424 (47.5%)		
The consumption of cereals, tubers, vegetables and fruit daily (g)				15.1	<0.001			13.9	<0.001
<800	1515	118 (7.8%)	1397 (92.2%)			916 (60.5%)	599 (39.5%)		
≥800	1462	176 (12.0%)	1286 (88.0%)			981 (67.1%)	481 (32.9%)		

LTPA: leisure-time physical activity; MVLTPA: moderate to vigorous leisure-time physical activity; LILTPA: low intensity of leisure-time physical activity; OR, odds rate.
†*p*-value is the result of a simple Chi-square test to examine whether association between sociodemographic information and leisure- time physical activity intensity, the frequency of milk intake respectively was statistically significant.

Table 2. Associations of LTPA intensity and the frequency of milk intake with newly diagnosed pathoglycemia

Item	N	Newly diagnosed pathoglycemia	Unadjusted		Model 1†		Model 2‡	
			p	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)
LTPA intensity								
MVLTPA	294	42 (14.3%)	0.002	0.584 (0.410-0.810)	0.022	0.663 (0.461-0.934)	0.033	0.681 (0.473-0.960)
LILTPA	2683	596 (22.2%)		1.000 (reference)		1.000 (reference)		1.000 (reference)
The frequency of milk intake								
>once/week	1897	370 (19.5%)	0.001	0.734 (0.614-0.878)	0.102	0.855 (0.708-1.032)	0.252	0.895 (0.739-1.083)
≤once/week	1080	201 (24.8%)		1.000 (reference)		1.000 (reference)		1.000 (reference)

LTPA: leisure-time physical activity; MVLTPA: moderate to vigorous leisure-time physical activity; LILTPA: low intensity of leisure-time physical activity; CI: confidence interval; OR: odds rate.
†Model 1 adjusted for age, gender, marital status, socioeconomic status and occupation.
‡Model 2 adjusted for BMI, smoking status, drinking status and the consumption of cereals, tubers, vegetables and, fruit daily based on Model 1.

Table 3. Synergistic associations of LTPA intensity and the frequency of milk intake with newly diagnosed pathoglycemia

LTPA intensity	The frequency of milk intake	N	Newly diagnosed pathoglycemia	Unadjusted		Model 1†		Model 2‡	
				p	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)
LILTPA	≤once/week	998	254 (25.5%)		1.000 (reference)		1.000 (reference)		1.000 (reference)
	>once/week	1685	342 (20.3%)	0.002	0.746 (0.620-0.898)	0.135	0.856 (0.705-1.042)	0.264	0.893 (0.732-1.090)
MVLTPA	≤once/week	82	14 (17.1%)	0.094	0.603 (0.321- 1.058)	0.120	0.630(0.331-1.1222)	0.138	0.638 (0.330-1.128)
	>once/week	212	28 (13.2%)	<0.001	0.446 (0.287-0.669)	0.020	0.593 (0.375- 0.908)	0.048	0.631 (0.403-0.982)

LTPA: leisure-time physical activity; MVLTPA: moderate to vigorous leisure-time physical activity; LILTPA: low intensity of leisure-time physical activity; CI: confidence interval; OR: odds rate.
†Model 1 adjusted for age, gender, marital status, socioeconomic status and occupation.
‡Model 2 adjusted for BMI, smoking status, drinking status and the consumption of cereals, tubers, vegetables, and fruit daily based on model 1.

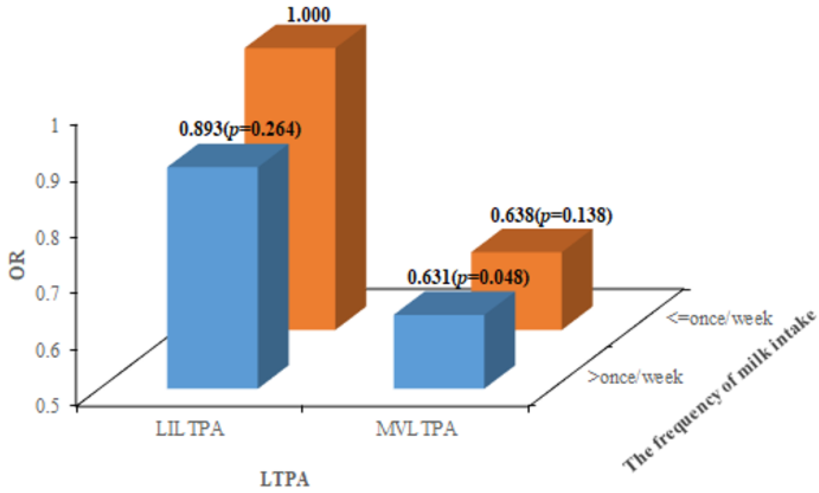

Figure 2. Synergistic associations of LTPA intensity and the frequency of milk intake with pathoglycemia. OR was calculated to estimate the synergistic associations in binary logistic regression after adjusting gender, age, marital status, socioeconomic status, occupation, BMI, smoking status, drinking status, the consumption of cereals, tubers, vegetables, and fruit daily, with the LILTPA and frequency of milk intake ≤once/week as the reference group. LTPA: leisure-time physical activity; MVLTPA: moderate to vigorous leisure-time physical activity; LILTPA: low intensity of leisure-time physical activity; OR: odds rate.

ergistic associations of LTPA intensity and the frequency of milk intake with newly diagnosed pathoglycemia. By contrast, previous studies have analyzed only the individual associations of dietary factors and PA with pathoglycemia, rather than the synergistic associations of PA and the frequency of milk intake. To the best of our knowledge, this study is the first to address the synergistic associations of LTPA intensity and the frequency of milk intake with pathoglycemia.

However, the study has several limitations. First, data on PA and the frequency of milk intake were self-reported by respondents. Because self-reports are potentially erroneous, such errors would have partially influenced our results. Second, except for LTPA intensity, we did not analyze the associations between the prevalence of pathoglycemia and other types of PA, including work-related PA, housework-related PA, and transportation-related PA. Third, types of milk, such as milk with different fat content, were not considered in our analysis. A future analysis that distinguishes types of milk may yield different results. Fourth, because our research design was cross-sectional, data on the incidence of pathoglycemia could not be obtained. Specifically, although our study focused on participants with newly diagnosed pathoglycemia, people who had developed pathoglycemia might change their behavior upon feeling discomfort from pathoglycemia. Such behavioral changes include increasing LTPA intensity and eating healthier food, which may result in an underestimation of the effect of LTPA intensity and the frequency of milk intake. Therefore, future interventional studies should be conducted to address this concern.

Conclusion

In summary, we determined that both MVLTPA and an enough frequency of milk intake were associated with a significantly lower risk of newly diagnosed pathoglycemia. This reduction in risk was greater when both MVLTPA and an enough frequency of milk intake occurred jointly. Therefore, an intervention study including the 2 factors should be performed.

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AUTHOR DISCLOSURES

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Supplementary table 1. Associations of LTPA intensity and the frequency of milk intake with newly diagnosed IFG and T2DM

Item	IFG				T2DM			
	N (%)	Unadjusted OR	Model 1† OR	Model 2‡ OR	N (%)	Unadjusted OR	Model 1† OR	Model 2‡ OR
LTPA intensity								
MVLTPA	23 (8.36)	0.559 (0.350-0.850)**	0.631 (0.391-0.975)*	0.650 (0.402-1.006)	19 (7.01)	0.617 (0.368-0.975)	0.712 (0.419-1.146)	0.729 (0.429-1.174)
LILTPA	341 (14.04)	1.000 (reference)	1.000 (reference)	1.000 (reference)	255 (10.89)	1.000 (reference)	1.000 (reference)	1.000 (reference)
The frequency of milk intake								
>once/week	212 (12.19)	0.742 (0.593-0.930)*	0.864 (0.685-1.094)	0.904 (0.714-1.147)	158 (9.38)	0.724 (0.117-0.172)*	0.881 (0.675-1.151)	0.910 (0.696-1.194)
≤once/week	152 (15.78)	1.000 (reference)	1.000 (reference)	1.000 (reference)	116 (12.50)	1.000 (reference)	1.000 (reference)	1.000 (reference)

LTPA: leisure-time physical activity; MVLTPA: moderate to vigorous leisure-time physical activity; LILTPA: low intensity of leisure-time physical activity; CI: confidence interval; OR: odds rate.
†Model 1 adjusted for age, gender, marital status, socioeconomic status, and occupation.
‡Model 2 adjusted for BMI, smoking status, drinking status and consumption of cereals, tubers, vegetables, and fruit daily based on model 1.
*p<0.05, **p<0.01.

Supplementary table 2. Synergistic associations of LTPA intensity and the frequency of milk intake with newly diagnosed IFG and T2DM

LTPA intensity	The frequency of milk intake	IFG				T2DM			
		N (%)	Unadjusted OR	Model 1† OR	Model 2‡ OR	N	Unadjusted OR	Model 1† OR	Model 2‡ OR
LILTPA	≤once/week	144 (16.2)	1.000 (reference)	1.000 (reference)	1.000 (reference)	110 (12.9)	1.000 (reference)	1.000 (reference)	1.000 (reference)
	>once/week	197 (12.8)	0.758 (0.601-0.958)*	0.869 (0.682-1.108)	0.904 (0.780-1.157)	145 (9.7)	0.730 (0.562-0.952)*	0.875 (0.665-1.154)	0.904 (0.780-1.157)
MVLTPA	≤once/week	8 (10.5)	0.608 (0.265-1.220)	0.622 (0.269-1.264)	0.623 (0.268-1.271)	6 (8.1)	0.597 (0.227-1.302)	0.633 (0.238-1.404)	0.623 (0.268-1.271)
	>once/week	15 (7.5)	0.421 (0.232-0.712)*	0.559 (0.303-0.967)*	0.606 (0.328-1.050)	13 (6.6)	0.478 (0.251-0.838)*	0.671 (0.345-1.212)	0.606 (0.328-1.050)

LTPA: leisure-time physical activity; MVLTPA: moderate to vigorous leisure-time physical activity; LILTPA: low intensity of leisure-time physical activity; CI: confidence interval; OR: odds rate.
†Model 1 adjusted for age, gender, marital status, socioeconomic status, and occupation.
‡Model 2 adjusted for BMI, smoking status, drinking status and consumptions of cereals, tubers, vegetables, and fruit daily based on model 1.
*p<0.05.