

Benefits of leisure-related physical activity and association between sedentary time and risk for hypertension and type 2 diabetes

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ABSTRACT

Introduction: Lifestyle modifications can reduce the risk of type 2 diabetes mellitus (T2DM) and hypertension. Our study investigated whether domain-specific physical activity (such as work, transport and leisure) and sedentary behaviour were associated with T2DM and hypertension, and whether these associations were moderated by sex and age.

Method: For this cross-sectional study, data were obtained from a population survey in Singapore (n=2,867) conducted from February 2019 to March 2020. T2DM and hypertension were self-reported. Global physical activity questionnaire was used to assess domain-specific physical activity (in metabolic equivalent of task [MET]-minutes) and sedentary time (in hours). Logistic regression models were generated to examine the abovementioned associations, and adjusted for age, sex, education, ethnicity, personal income, body mass index, diet and hypertension/diabetes. Interaction terms were included individually to investigate whether age and sex moderated the associations.

Results: Individuals with >826 MET-minutes of leisure-related physical activity per week had lower odds of having T2DM (odds ratio [OR] 0.46, 95% confidence interval [CI] 0.24–0.86) and hypertension (OR 0.59, 95% CI 0.37–0.94) than those with no leisure-related physical activity. Individuals with >8 hours of sedentary time daily had higher odds of having hypertension (OR 1.69, 95% CI 1.06–2.69) than those with 0–5 hours of sedentary time. Logistic regression models including interaction terms showed that the association between leisure-related physical activity and hypertension was significant for those aged 18–34 (OR 0.15, 95% CI 0.03–0.66) and 50–64 years (OR 0.44, 95% CI 0.21–0.91). The association between sedentary time and hypertension was significant for those aged 18–34 years (OR 15.07, 95% CI 1.69–133.92).

Conclusion: Our results support the widespread promotion of an active lifestyle to lower the prevalence of diabetes and hypertension in Singapore.

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Keywords: Active lifestyle, domain-specific physical activity, global physical activity questionnaire

INTRODUCTION

Diabetes mellitus and hypertension are serious public health issues. Approximately 451 million individuals worldwide aged 18–99 years were living with diabetes in 2017, and this number is expected to increase to 693 million by 2045.¹ More than 90% of all diabetes cases were type 2 diabetes mellitus (T2DM).² For hypertension, 1.39 billion adults were estimated to have the condition globally in 2010.³ These chronic conditions

can lead to illnesses with high mortality and morbidity, such as stroke and kidney diseases.^{4,5} Although epidemiological studies have established that higher physical activity and lower sedentary time can reduce the risk of diabetes and hypertension,^{6–9} significant gaps remain in existing literature.

Firstly, most studies focus on total physical activity or leisure-related physical activity. Emerging literature has suggested that higher physical activity in other domains

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CLINICAL IMPACT

What is New

- Higher leisure-related physical activity was associated with lower odds of diabetes and hypertension.
- Higher sedentary time was associated with higher odds of hypertension.
- The associations between hypertension with leisure-related physical activity and sedentary behaviour vary with age.

Clinical Implications

- Health-promoting organisations can emphasise that low and moderate levels of leisure-related physical activities are better than none.
- Our findings suggest that heightened encouragement to adopt a healthy lifestyle can benefit individuals aged 18–34 and 50–64 years, who are more susceptible to hypertension.

(work and transport) can also lower the risk of diabetes and hypertension, although findings differ across countries and sociodemographic groups.^{6–9} A study in the US showed that higher physical activity in all domains (occupation, transport and leisure) lowered the odds of having diabetes.⁷ However, a study in Korea found that among men, higher leisure- and transport-related physical activities were associated with lower odds of having diabetes.⁶ For women, only higher leisure-related physical activity was associated with lower odds of having diabetes. Work-related physical activity was not associated with diabetes for both sexes.⁶

Secondly, although the effects of leisure-related physical activity and sedentary behaviour on diabetes and hypertension were well-established, the associations between their intensity with diabetes and hypertension vary across sociodemographic groups.¹⁰ A study in Brazil revealed that only men who were sufficiently active in the leisure domain had a lower risk of hypertension (odds ratio [OR] 0.84) than those who were inactive.¹⁰ Conversely, women who were insufficiently active (OR 0.88) and sufficiently active (OR 0.86) in the leisure domain had a lower risk of hypertension than those who were inactive.¹⁰ Another study in Korea found that the association between the length of leisure sedentary time with hypertension and diabetes depends on occupation.¹¹

Singapore is a Southeast Asian country with a multiethnic population comprising 75.9% Chinese, 15.0% Malay, 7.5% Indian and 1.6% of other races.¹² The prevalence of diabetes was 9.5% in the period 2019–2020, with a projected increase to 15.9% by 2050.^{13,14} Hypertension was estimated to have a prevalence of 35.5% in the period 2019–2020.¹⁴ To counter the rise in these chronic conditions, policymakers in Singapore have been promoting a healthy lifestyle through population-wide campaigns. One initiative is the National Steps Challenge, a campaign that encourages individuals to be physically active by providing wearables to monitor their steps and heart rate, with financial incentives if certain targets are met.¹⁵

Few studies in Singapore have looked at the widespread promotion of a healthy lifestyle in reducing the risk of T2DM and hypertension.¹⁶ Müller-Riemenschneider et al. have revealed that in Singapore, having a higher level of total leisure-time physical activity was associated with lower diastolic blood pressure.¹⁶ However, having lower diastolic and systolic blood pressure were associated with specific leisure-time physical activities, such as balance exercises (e.g. tai chi and qigong).¹⁶ These associations differed across ethnicities.¹⁶ Limited studies in Singapore have considered the associations between other domain-specific physical activities and sedentary behaviour with hypertension. Furthermore, few studies in Singapore have examined the relationship between domain-specific physical activities and sedentary behaviour with T2DM.¹⁶

Hence, our study aimed to examine (1) the prevalence of T2DM and hypertension for different levels of domain-specific physical activity (work, transport and leisure) and sedentary time; (2) the association between domain-specific physical activity and sedentary time with T2DM and hypertension; and (3) whether sex and age moderate these associations.

METHOD

The data for this cross-sectional analysis were obtained from a population survey intended to understand the knowledge, attitude and practice of diabetes in Singapore (n=2,895), with a response rate of 66.2%.¹⁷ When stratified by ethnicity, the response rates were as follows: 58.3% for Chinese, 69.3% for Malay, 71.0% for Indian and 66.6% for others. The study was approved by the Institute of Mental Health Institutional Research Committee and the National Healthcare Group Domain-Specific Review Board (reference number: 2018/00430). Written informed consent was obtained from all participants. Parental consent was also obtained

for participants aged 18–20 years. Our analysis utilised data collected from February 2019 to March 2020 ($n=2,867$). Data collected from 1 April 2020 to 1 September 2020 were excluded ($n=28$) due to COVID-19 restrictions and social distancing measures, which may have affected physical activity and sedentary time.

The study protocol was described in detail in a previous publication.¹⁷ Briefly, the participants recruited were Singaporeans or permanent residents who lived in Singapore during the study period, aged 18 or above, and fluent in English, Malay, Mandarin or Tamil. Individuals with the following criteria were excluded from the study: age below 18 years, uncontactable due to missing or incomplete address, resided outside Singapore, were institutionalised throughout the study period, or had difficulties completing the survey due to physical, mental or cognitive disability.

One to 2 weeks before the house visit by an interviewer, an invitation letter was sent to the address of potential participants. The letter included information about the survey and a contact number for any enquiries. Data were collected using computer-assisted personal interviews with handheld tablets. If the participant was not at home, a card with the contact details of the interviewer was left behind. A maximum of 10 visits were conducted to reduce the non-response rate. After completing the survey, the participant was given an inconvenience fee.

A disproportionate stratified sampling was performed using the national administrative database to ensure that the sample was representative of the Singapore population.¹⁷ The percentage of participants for each ethnic group (Chinese, Malay and Indian) was set at approximately 30%. The proportion of participants for each age group (18–34, 35–49, 50–65, and >65 years) was fixed at 20%.

Variables: Outcomes and correlates of interest

The outcomes were self-reported T2DM and hypertension. A random sample of participants who reported no diabetes ($n=250$) was selected to have their fasting glucose and glycosylated haemoglobin (HbA1c) measured via a blood test. The result showed that only a small proportion of the sample ($n=19$, <10%) had undiagnosed diabetes. The variables of interest were physical activity per week and sedentary behaviour daily, which were self-reported using the 16-item global physical activity questionnaire (GPAQ).¹⁸ Moderate and vigorous physical activities were determined in 3 domains: work, transport and leisure. Physical activities are defined as moderate if they lead to a slight rise in breathing or heart

rate for at least 10 minutes.¹⁸ Physical activities are considered vigorous if they cause a considerable rise in breathing or heart rate for at least 10 minutes.¹⁸ We calculated the energy expenditure for each domain by multiplying the time variables for each physical activity intensity with metabolic equivalent (MET) values, followed by adding the values for both moderate and vigorous physical activity.¹⁸ Sedentary behaviour was assessed by asking the time spent sitting or reclining during a day.¹⁸ GPAQ was appropriate to assess physical activity and sedentary behaviour because studies in Singapore have shown a moderate correlation between GPAQ and accelerometer-measured physical activity and sedentary behaviour.^{19,20}

Control variables

Based on literature,^{8,16,21,22} the following control variables were included: age, sex, education, ethnicity, personal income, body mass index (BMI) and Dietary Approaches to Stop Hypertension (DASH) score. The DASH score was calculated based on the responses from the diet screener that was developed and well-validated in Singapore.²³ It assesses food intake by asking participants to rate the frequency of each food/beverage they normally consumed in the previous year using a 10-point scale, ranging from “never/rarely” to “6 or more times per day”.

Statistical analysis

Analyses were weighted to adjust for oversampling and post-stratification by ethnicity and age. As a substantial portion of participants had 0 MET-minute for each domain-specific physical activity, we divided each domain-specific physical activity into 3 groups at 0 MET-minute and the mean. This classification method was similarly utilised for another study in Singapore.¹⁶ Sedentary time was divided into tertiles: 0–5 hours, >5–8 hours and >8 hours. The prevalence of diabetes and hypertension stratified by sociodemographic groups, domain-specific physical activities and sedentary behaviour were presented in weighted percentages and unweighted counts.

The associations between domain-specific physical activity and sedentary behaviour with diabetes and hypertension were examined via logistic regression. The models were controlled for age, sex, education, ethnicity, personal income and DASH score. Additional models were run to adjust for BMI and diabetes/hypertension, which were potential mediators.^{6,16,24} To determine whether the significant associations identified differ by sex and age group, we individually included

2-way interaction terms in the model. The results were presented in OR and 95% confidence interval (CI). Standard errors were computed using Taylor series linearisation to account for the complex survey sampling design.

All analyses were performed using STATA/MP 17.0 (Stata Corporation, College Station, Texas, US) with a two-sided test at a 5% significance level. All missing data were handled in a listwise manner.

RESULTS

Our study included 2,867 participants. The prevalence of T2DM and hypertension were 8.4% and 20.7%, respectively. Table 1 summarises the prevalence of T2DM and hypertension stratified by sociodemographic groups, domain-specific physical activities, sedentary behaviour and DASH score. The prevalence of T2DM was relatively higher for those aged 65 and above (20.7%), males (9.90%), of Indian ethnicity (14.2%), with primary school qualifications (16.4%), with an income level below SGD2,000 (12.1%) and in the obese BMI range (17.0%). The prevalence of hypertension was relatively higher for those aged 65 and older (52.6%), males (22.4%), those of Chinese ethnicity (21.4%), with primary school education (43.3%), with income less than SGD2,000 (27.5%) and in the obese BMI range (32.2%). The cross-tabulation of age groups

and the various domain of physical activity were previously published by Lau et al.²⁵

The prevalence of T2DM and hypertension were relatively higher for participants who reported no work-related (T2DM: 9.7%, hypertension: 22.3%) and leisure-related physical activity (T2DM: 13.6%, hypertension: 29.2%). The prevalence of these chronic conditions was similar across different levels of transport-related physical activities and sedentary behaviour. The mean DASH score was similar for participants with T2DM (20.5) and no T2DM (18.9), and participants with hypertension (20.0) and no hypertension (18.8).

Table 2 presents the regression models with T2DM and hypertension as outcomes. Compared to participants with 0 MET-minute of leisure-related physical activity, participants with >826 MET-minutes of leisure-related physical activity had lower odds of having T2DM (OR 0.46, 95% CI 0.24–0.86). The dose-response relationship for leisure-related physical activity was significant ($p_{\text{trend}}=0.016$). For T2DM, no significant interaction effects were observed for sex and age groups.

Compared to participants with 0 MET-minute of leisure-related physical activity, higher leisure-related physical activity was associated with lower odds of having hypertension (OR of >826 MET-minutes 0.59, 95% CI 0.37–0.94) but higher sedentary time was

Table 1. Prevalence of type 2 diabetes mellitus and hypertension by sociodemographic, domain-specific physical activities, sedentary behaviour and DASH score.

	T2DM (n=2867)				Hypertension (n=2849)			
	Yes (n=384)		No (n=2,483)		Yes (n=663)		No (n=2186)	
	n	%	n	%	n	%	n	%
Age group, years								
18–34	4	0.2	810	99.8	19	1.8	793	98.3
35–49	45	3.8	666	96.2	79	11.9	628	88.1
50–64	166	15.5	600	84.5	253	33.2	505	66.8
65 and above	169	20.7	407	79.3	312	52.6	260	47.4
Sex								
Female	188	7.1	1270	93.0	328	19.1	1122	80.9
Male	196	9.9	1213	90.1	335	22.4	1064	77.6
Ethnicity								
Chinese	61	7.3	730	92.7	177	21.4	610	78.6
Malay	143	11.9	818	88.1	241	20.0	713	80.0
Indian	165	14.2	743	85.8	204	16.7	698	83.3
Others	15	4.4	192	95.6	41	15.4	165	84.6

Table 1. Prevalence of type 2 diabetes mellitus and hypertension by sociodemographic, domain-specific physical activities, sedentary behaviour and DASH score. (Cont'd)

	T2DM (n=2867)				Hypertension (n=2849)			
	Yes (n=384)		No (n=2483)		Yes (n=663)		No (n=2186)	
Educational level								
Primary	148	16.4	483	83.6	273	43.3	351	56.7
Secondary	121	11.5	560	88.5	192	24.3	485	75.7
A-level/polytechnic/ vocational school/ITE ^a	71	5.7	789	94.3	112	13.1	744	87.0
Degree and above	44	3.5	651	96.5	86	10.5	606	89.5
Income level (SGD)								
Below 2000	259	12.1	1182	87.9	435	27.5	997	72.5
2000–5999	84	5.7	922	94.3	168	16.3	832	83.7
6000 and above	28	4.9	268	95.1	42	13.9	253	86.1
BMI classification (international)								
Normal range	104	5.2	1149	94.8	219	16.7	1027	83.3
Underweight	3	1.4	147	98.7	12	6.0	137	94.0
Overweight	132	11.8	716	88.2	214	25.4	632	74.6
Obese	85	17.0	330	83.0	130	32.2	279	67.8
Work-related physical activity								
0 MET-minute	203	9.7	1069	90.3	334	22.3	932	77.7
>0–805 MET-minutes	79	6.4	661	93.6	173	21.4	561	78.6
>1805 MET-minutes	102	7.8	753	92.2	156	16.1	693	83.9
Transport-related physical activity								
0 MET-minute	93	8.5	497	91.5	166	22.4	419	77.6
>0–1028 MET-minutes	196	8.4	1277	91.6	343	19.9	1121	80.1
>1038 MET-minutes	95	8.3	709	91.7	154	20.7	646	79.3
Leisure-related physical activity								
0 MET-minute	199	13.6	782	86.4	319	29.2	651	70.9
>0–826 MET-minutes	115	7.5	819	92.5	217	20.5	716	79.5
>826 MET-minutes	70	4.3	882	95.7	127	12.5	819	87.5
Sedentary behaviour								
0–5 hours	157	9.5	1049	90.5	285	22.4	912	77.6
>5–8 hours	117	8.3	792	91.7	195	20.1	708	79.9
>8 hours	109	6.9	642	93.1	182	18.7	566	81.3
Mean DASH score (SD)	20.5 (6.1)		18.9 (4.4)		20.0 (4.8)		18.8 (4.5)	

BMI: body mass index; DASH: Dietary Approaches to Stop Hypertension; ITE: Institute of Technical Education; MET: metabolic equivalent of task; SD: standard deviation

Number of missing data: Income level (n for diabetes = 124, n for hypertension = 122),

BMI classification (n for diabetes = 201, n for hypertension = 199), sedentary behaviour (n for diabetes = 1, n for hypertension = 1).

^a These are post-secondary educational qualifications.

Table 2. Logistic regression with diabetes and hypertension as the outcome.

	T2DM outcome				Hypertension outcome			
	Model 1 ^a		Model 2 ^b		Model 1 ^a		Model 2 ^c	
	OR (95% CI)	Linear P _{trend}	OR (95% CI)	Linear P _{trend}	OR (95% CI)	Linear P _{trend}	OR (95% CI)	Linear P _{trend}
Work-related physical activity		0.554		0.781		0.735		0.867
0 MET-minute (Reference)								
>0–1805 MET-minutes	0.65 (0.39–1.10)		0.64 (0.36–1.14)		1.08 (0.73–1.58)		1.24 (0.82–1.89)	
>1805 MET-minutes	0.86 (0.52–1.42)		0.93 (0.55–1.56)		0.93 (0.60–1.43)		1.04 (0.66–1.64)	
Transport-related physical activity		0.969		0.897		0.454		0.604
0 MET-minute (Reference)								
>0–1028 MET-minutes	0.94 (0.56–1.58)		1.04 (0.57–1.89)		0.67 (0.45–1.01)		0.69 (0.44–1.10)	
>1028 MET-minutes	0.99 (0.56–1.74)		0.96 (0.51–1.80)		0.84 (0.52–1.34)		0.87 (0.52–1.47)	
Leisure-related physical activity		0.003		0.016		0.005		0.025
0 MET-minute (Reference)								
>0–826 MET-minutes	0.74 (0.46–1.16)		0.77 (0.47–1.28)		1.03 (0.70–1.53)		1.07 (0.70–1.64)	
>826 MET-minutes	0.41 (0.23–0.73)		0.46 (0.24–0.86)		0.54 (0.35–0.83)		0.59 (0.37–0.94)	
Sedentary behaviour		0.500		0.889		0.014		0.026
0–5 hours (Reference)								
>5–8 hours	1.17 (0.73–1.87)		1.17 (0.69–2.01)		1.27 (0.87–1.85)		1.32 (0.88–1.99)	
>8 hours	1.21 (0.70–2.08)		0.96 (0.53–1.73)		1.70 (1.11–2.60)		1.69 (1.06–2.69)	

CI: confidence interval; DASH: Dietary Approaches to Stop Hypertension; MET: metabolic equivalent of task; OR: odds ratio; SD: standard deviation; T2DM: type 2 diabetes mellitus

^a Adjusted for age, sex, ethnicity, education, personal income and DASH score.^b Additionally adjusted for body mass index (international) and hypertension.^c Additionally adjusted for body mass index (international) and T2DM.Bold values indicate statistical significance ($P < 0.05$).

associated with higher odds of hypertension (OR of >8 hours 1.69, 95% CI 1.06–2.69). The dose-response effects for leisure-related physical activity ($p_{\text{trend}}=0.025$) and sedentary time ($p_{\text{trend}}=0.026$) were significant.

Including interaction terms in the model showed that the associations between hypertension with leisure-related physical activity and sedentary behaviour were moderated by age group (online Supplementary Table S1). Table 3 presents the ORs for these associations by age group. Among participants aged 18–34 and 50–64 years, those who engaged in >826 MET-minutes of leisure-related physical activity had lower odds of having hypertension (OR for 18–34 years 0.15, 95% CI 0.03–0.66; OR for 50–64 years 0.44, 95% CI 0.21–0.91) than those who did not engage in leisure-related physical activity. For participants aged 18–34 years, higher odds of having hypertension were observed for those with >8 hours of sedentary behaviour than those with 0–5 hours of sedentary behaviour (OR 15.07, 95% CI 1.69–133.92).

DISCUSSION

Our study showed that those who did not participate in work-related and leisure-related physical activities had higher prevalence of T2DM and hypertension. Moreover, the odds of having T2DM were lower for participants with higher levels of leisure-related physical activity. Higher levels of leisure-related physical activity were associated with lower odds of hypertension, whereas higher sedentary time was associated with higher odds of hypertension. Furthermore, a high level of leisure-related physical activity (>826 MET-minutes) was associated with lower odds of hypertension for participants aged 18–34 and 50–64 years. A high level of sedentary time (>8 hours) was associated with higher odds of hypertension among those aged 18–34 years.

Our findings on the association between leisure-related physical activity and T2DM is in line with previous studies. A cohort study among Japanese workers revealed that the hazard of T2DM was 0.17 times lower for those with ≥ 15 MET-hours of leisure-time exercise than those with no leisure-time exercise.²⁶ Lee et al. also found that in Korea, higher leisure-related physical activity (≥ 600 MET-minutes/week) lowered the odds of having diabetes for men by 0.15 times and women by 0.27 times.⁶ Other studies have demonstrated that exercise can enhance insulin sensitivity for a minimum of 16 hours after exercise and raise glucose absorption stimulated by insulin.^{27,28}

Related studies have corroborated our findings on the associations of leisure-related physical activity and sedentary behaviour with hypertension. A meta-analysis

Table 3. Adjusted odd ratios for leisure-related physical activity-by-age interactions.

	Hypertension OR (95% CI)
Leisure-related physical activity	
>0–826 MET-minutes versus 0 MET-minute	
18–34 years old	0.89 (0.18–4.49)
35–49 years old	0.83 (0.38–1.79)
50–64 years old	1.03 (0.56–1.87)
≥ 65 years old	1.36 (0.58–3.22)
>826 MET-minutes vs 0 MET-minute	
18–34 years old	0.15 (0.03–0.66)
35–49 years old	0.47 (0.19–1.16)
50–64 years old	0.44 (0.21–0.91)
≥ 65 years old	1.18 (0.55–2.56)
Sedentary behaviour	
>5–8 hours vs 0–5 hours	
18–34 years old	7.46 (0.71–78.8)
35–49 years old	1.74 (0.72–4.26)
50–64 years old	1.08 (0.59–1.97)
≥ 65 years old	1.41 (0.66–2.99)
>8 hours vs 0–5 hours	
18–34 years old	15.07 (1.69–133.92)
35–49 years old	1.72 (0.70–4.20)
50–64 years old	1.75 (0.91–3.38)
≥ 65 years old	1.30 (0.52–3.25)

CI: confidence interval; DASH: Dietary Approaches to Stop Hypertension; MET: metabolic equivalent of task; OR: odds ratio

Adjusted for age, sex, education, ethnicity, personal income, DASH score, body mass index (international) and diabetes.

Bold values indicate statistical significance ($P<0.05$).

of prospective cohort studies revealed that the risk of hypertension was lowered by 0.19 times for high leisure-related physical activity.²⁹ Another meta-analysis showed that a unit increase in total sedentary behaviour raises the risk of hypertension by 4%.³⁰ Biological studies have also found that exercise training can reduce the risk of hypertension by producing more nitric oxide, which leads to endothelial vasodilation.³¹ Moreover, higher nitric oxide can result in angiogenesis, a process that increases the size and number of blood vessels, and individuals with higher sedentary time produce fewer

vasodilator metabolites due to low metabolic demand.³² Moreover, their blood vessels in the lower limbs are narrowed due to seated posture.³² These processes increase peripheral resistance of the blood vessels and lead to a higher risk of hypertension.³²

Our results showed that the associations between hypertension with leisure-related physical activity and sedentary behaviour vary with age. Although limited epidemiological studies have considered the moderating effect of age on the association between leisure-related physical activity and hypertension, several intervention studies have examined how physical activity can influence endothelium-dependent vasodilation in different age groups. For young adults, a study on a 10-week exercise programme on healthy male military recruits (aged 17–24 years) showed that the programme improved the mean flow-mediated dilation of the intervention group from 2.2% to 3.9%.³³ For older adults, a study showed that a 3-month aerobic exercise programme for males aged 50–76 years enhanced acetylcholine-mediated vasodilation by 30%.³⁴ However, our findings only showed significant associations between leisure-related physical activity and hypertension among those aged 18–34 and 50–64 years. As we could not explain the lack of association among those aged 35–49 years and those 65 years and above, future studies could explore the reasons for these phenomena.

Although a few studies have examined the moderating effect of age on the association between sedentary behaviour and hypertension, the results were different from our findings. A study that examined the health correlates of hypertension among college students revealed that weekly sitting time was not significantly associated with hypertension.³⁵ Similarly, another study showed no significant association between sedentary behaviour and blood pressure among university students.³⁶ This difference could be related to the diverse instruments used to measure sedentary behaviour.

Our study has several implications for health promotion strategies. Firstly, the dose-response association between leisure-related physical activity with T2DM suggests that individuals with higher leisure-related physical activity had a lower prevalence of diabetes (Reference group: 0 MET-minute). Hence, although engaging in >826 MET-minutes of leisure-related physical activity will be more beneficial, health-promoting organisations can still emphasise that small and moderate levels of leisure-related physical activities are better than none. Secondly, participants with higher levels of sedentary time had a high prevalence of hypertension. Hence,

reducing the hours of sedentary time, even slightly, may be beneficial in reducing the prevalence of hypertension.

Thirdly, our results showed that the associations between domain-specific physical activity and sedentary time with T2DM and hypertension were significant in certain age groups. As our study was cross-sectional, we could not infer whether physical activity or sedentary time can prevent T2DM or hypertension over time. Nonetheless, our findings suggest that more could be done to encourage a healthy lifestyle for individuals in these age groups. A previous publication by Subramaniam et al.³⁷ has identified several barriers and facilitators of adopting a healthy lifestyle in Singapore. However, these barriers and facilitators focused on physical activity and nutrition. Future research can explore the reasons for a high sedentary time among individuals aged 50–64 years. Knowing these reasons can help to formulate strategies that disrupt long hours of sedentary time.

Our results are generalisable to the Singapore population since the data are from a nationwide survey. Nevertheless, our study has several limitations. Firstly, the presence of T2DM and hypertension were self-reported. However, <10% of our random sample of participants with no reported diabetes were undiagnosed. Furthermore, studies have shown that self-reported diagnosis is accurate.^{38,39} A study by Hansen et al.³⁸ found a good agreement between self-reported diabetes and practitioner-reported diabetes. Self-reported hypertension also had a moderate agreement with practitioner-reported hypertension.³⁸ Secondly, we could not account for confounders that were not collected in the study, such as smoking status.^{9,16,40} Lastly, we could not infer causality due to the cross-sectional study design. For instance, those with hypertension may be advised to improve their physical activity. Hence, the association between leisure-related physical activity and hypertension may be hard to detect in our study.

CONCLUSION

Our study showed that higher levels of leisure-related physical activity was associated with a lower odds of having T2DM and hypertension. Furthermore, sedentary behaviour was positively associated with hypertension. Future studies could explore the reasons for a high sedentary time among individuals aged 50–64 years. By quantifying these associations, relevant organisations in Singapore can better promote the health benefits of increasing leisure-related physical activity and reducing sedentary time.

Disclosure

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