

The Effect of Leisure-time Physical Activity on Obesity, Diabetes, High BP and Heart Disease among Canadians: Evidence from 2000/01 to 2005/06

Sisira Sarma, Assistant Professor
Department of Epidemiology & Biostatistics
Schulich School of Medicine & Dentistry
The University of Western Ontario
ssarma2@uwo.ca
Sisira.Sarma@schulich.uwo.ca

Co-authors: Rose Anne Devlin, Jason Gilliland, M. Karen Campbell, Gregory Zaric

Outline

- **Introduction**
- **Methodology**
- **Data and Variables**
- **Results**
- **Conclusion**

Introduction

- **Public Health/Epidemiology Literature**
- Negative associations between leisure-time physical activity and obesity/chronic conditions
- The identified associations may not be causal
 - Unobserved heterogeneity bias
 - Reverse causality bias
 - Exclusion of work-related physical activity
 - Self-reported global physical activity: may not capture intensity, frequency and duration

Introduction cont.

- **Health Economics Literature**

- Accounting for endogeneity of physical activity has no effect or very small effect on obesity (Rashad, 2006; Maitra and Sharma, 2007)

- LTPA reduces the probability of diabetes, high blood pressure (BP), heart disease, asthma, arthritis and self-reported poor health (Humphreys et al., 2013)

Research Questions

- Is there a negative association between LTPA and Obesity in Canada?
- Is there a negative association between LTPA and Chronic Conditions (Diabetes, high BP, Heart Disease) in Canada?
- Do these associations persist once endogeneity of LTPA is accounted for?
- How the effects of LTPA on Obesity and Chronic Conditions vary across WRPA levels?

Methodology

- A reduced-form model of obesity (or chronic condition) a la Humphreys *et al.* (2013), but include WRPA:

$$H_i^* = \alpha + \delta_1 LTPA_i^* + \delta_2 WRPA_i + \beta' X_i + \varepsilon_i$$

- $H_i = 1$ if $H_i^* \geq 1$ and 0 otherwise

$$LTPA_i^* = \eta + \lambda' Z_i + \gamma' X_i + u_i$$

- $LTPA_i = 1$ if $LTPA_i^* \geq 1$ and 0 otherwise

Methodology cont.

- H_i : Overweight (overweight or obese = 1, 0 normal weight), Obese (obese = 1, 0 normal weight)
- Diabetes, High BP, Heart Disease (diagnosed with a chronic condition = 1, 0 otherwise)
- Three LTPA dummy variables (based on average daily energy expended on all leisure activities undertaken by the respondent over a three-month period): **Daily, Moderate, Active**

Methodology cont.

- Three Econometric Approaches:
 - Univariate Probit
 - Instrumental Variable (IV)
 - Recursive Bivariate Probit (BP)
- Average Partial Effects (Probit):

$$\frac{1}{n} \sum_1^n \left[\Phi \left(\hat{\beta} X_i + \hat{\delta}_2(WRPA_i) + \hat{\delta}_1(LTPA_i) \mid LTPA = 1 \right) - \Phi \left(\hat{\beta} X_i + \hat{\delta}_2(WRPA_i) + \hat{\delta}_1(LTPA_i) \mid LTPA = 0 \right) \right]$$

Methodology cont.

- A linear IV yields consistent estimates (Imbens and Angrist, 1994; Angrist et al., 1996)
 - Coefficient interpreted as the local average treatment effect
- A correctly specified bivariate probit model is superior to the IV procedure, especially if the error term is non-normal (Bhattacharya et al., 2006; Freedman and Sekhon 2010)
 - Average partial effects approximate average treatment effects

Methodology cont.

- Identification requirements for IV and recursive bivariate probit models
 - Z_i must be strongly correlated with LTPA
 - Z_i needs to be uncorrelated with $\varepsilon_i | X_i$
- Humphreys et al. (2013): a dummy variable on the “sense of belonging to the local community”
 - 1) live in areas with adequate local amenities, including physical activity related facilities
 - 2) a falsification test (food allergies and glaucoma where LTPA is insignificant)

Methodology cont.

- Problem with the “sense of belonging to the local community” as an instrument:
- It is strongly associated with better health outcomes in Canada (Ross, 2002; Wister and Wanless, 2007; Shields, 2008; Romans et al., 2011; Kitchen et al., 2012) and higher social capital (Wister and Wanless, 2007; Laporte et al., 2008; Kitchen et al., 2012)
- Exogeneity of their Z_i is called into question as it seems correlated with both LTPA and H_i

Methodology cont.

- We use monthly average temperatures in the respondents' local neighbourhood
- **Several Steps Involved**
- Geocode 6-digit residential postal codes in CCHS -- obtain longitude and latitude coordinates
- Monthly average temperature along with longitude and latitude coordinates of weather stations/year
- Assign the nearest weather station to each respondent in each year using ArcGIS software
- Link monthly average temperature for everyone back three months (beginning with the interview month)

Methodology cont.

- Analysis is restricted to those observations where a weather station is found within 0.5 degree (about 55 kilometers) distance
- Merchant et al. (2007)
 - Winter season: 64% of Canadians are inactive
 - Summer Season: 49% of Canadians are inactive
 - Varying considerably across geography
- Weather accounts for over 40% of all measured physical activity (Tucker and Gilliland, 2007)

Methodology cont.

Month of Interview	Sample	% of CCHS Sample	Mean Temp. (°C)	Std. Dev	Min (°C)	Max (°C)
CCHS Cycle 1.1						
Month (t)	93,162	87.72%	6.87	10.56	-32.6	24
Month (t-1)	93,123	87.68%	6.93	10.73	-31	24
Month (t-2)	93,046	87.61%	6.52	10.97	-31	24
CCHS Cycle 2.1						
Month (t)	91,798	87.93%	7.29	10.80	-35.2	24.6
Month (t-1)	91,766	87.90%	6.40	11.19	-35.2	24.6
Month (t-2)	91,590	87.73%	5.21	11.49	-35.5	24.6
CCHS Cycle 3.1						
Month (t)	93,661	89.00%	8.38	10.26	-32.7	24.6
Month (t-1)	93,646	89.99%	7.79	10.89	-32.7	24.6
Month (t-2)	93,288	88.65%	6.87	11.26	-32.5	24.6

Data and Variables

- Master files of the Canadian Community Health Survey (CCHS), Cycles 1.1 (2000/01), 2.1 (2003/04), 3.1 (2005/06)
- Each CCHS cycle is a large nationally representative survey of > 130,000 individuals aged 12 or older living in all provinces and territories in Canada
- Analysis is restricted to those aged 18 to 75 years in each cycle
- 315,833 valid observations (excluding missing socio-demographic variables other than income)

Data and Variables

- Three LTPA dummy variables (based on average daily energy expended on all leisure activities undertaken by the respondent over a three-month period)
- **Daily:** Participates in LTPA daily, on average, lasting over 15 minutes = 1, 0 otherwise
- **Moderate:** Average daily energy expenditure value ≥ 1.5 kcal/kg/day, 0 otherwise
- **Active:** Average daily energy expenditure value ≥ 3 kcal/kg/day, 0 if average daily energy expenditure value < 1.5 kcal/kg/day

Data and Variables cont.

- WRPA (usual daily activities or work habits over past 3 months):
 - **Sedentary:** Usually sit during the day and don't walk around very much
 - **Stand/Walk:** Usually stand or walk quite a lot during the day but don't have to carry or lift things very often
 - **Light Load:** Usually lift or carry light loads, or have to climb stairs or hills often
 - **Heavy Load:** Usually do heavy work or carry very heavy loads

Data and Variables cont.

X_i : Age, Age², gender, marital status (currently married or common-law, and widows, separated and divorced); presence of children in the family (children < 6 and children < 12); Immigration status (0-10 and 11 years or more since immigration to Canada); educational status (secondary, some post-secondary and post-secondary degree); employment status, household income (\$20,000 to \$50,000, \$50,000 to \$80,000, > \$80,000 and missing dummy), home ownership; urban, and province of residence, time dummies

Results: Probit

LTPA/ WRPA	Overweight	Obese	Diabetes	High BP	Heart Disease
Daily	-.028*** (.003)	-.066*** (.004)	-.002* (.001)	-.012*** (.002)	-.004*** (.001)
Stand/Walk	-.028*** (.004)	-.051*** (.004)	-.012*** (.001)	-.015*** (.002)	-.008*** (.001)
Light Load	-.032*** (.004)	-.058*** (.004)	-.018*** (.002)	-.027*** (.003)	-.015*** (.001)
Heavy Load	-.007 (.006)	-.026*** (.007)	-.019*** (.002)	-.020*** (.004)	-.017*** (.003)
Obs.	269,506	166,284	298,250	297,960	298,154

Results: Probit cont.

LTPA/ WRPA	Overweight	Obese	Diabetes	High BP	Heart Disease
Moderate	-.026*** (.003)	-.068*** (.003)	-.008*** (.001)	-.019*** (.002)	-.006*** (.001)
Stand/Walk	-.028*** (.004)	-.050*** (.004)	-.011*** (.001)	-.014*** (.002)	-.008*** (.001)
Light Load	-.032*** (.004)	-.057*** (.004)	-.017*** (.002)	-.026*** (.003)	-.014*** (.001)
Heavy Load	-.008 (.006)	-.026*** (.007)	-.018*** (.002)	-.019*** (.004)	-.017*** (.002)
Obs.	269,506	166,284	298,250	297,960	298,154

Results: Probit cont.

LTPA/ WRPA	Overweight	Obese	Diabetes	High BP	Heart Disease
Active	-.041*** (.004)	-.101*** (.004)	-.011*** (.001)	-.028*** (.002)	-.008*** (.001)
Stand/Walk	-.032*** (.004)	-.056*** (.005)	-.012*** (.001)	-.015*** (.002)	-.008*** (.001)
Light Load	-.036*** (.005)	-.062*** (.006)	-.018*** (.002)	-.025*** (.003)	-.015*** (.002)
Heavy Load	-.011* (.007)	-.034*** (.008)	-.020*** (.003)	-.019*** (.005)	-.017*** (.003)
Obs.	200,408	124,351	222,557	222,346	222,486

Results: Probit (Sedentary)

LTPA	Overweight	Obese	Diabetes	High BP	Heart Disease
WRPA: Sedentary					
Daily	-.033*** (.006)	-.080*** (.008)	-.002 (.003)	-.015*** (.004)	-.008*** (.003)
Obs.	61,201	38,953	68,390	68,315	68,370
Moderate	-.037*** (.006)	-.091*** (.007)	-.013*** (.003)	-.023*** (.004)	-.009*** (.002)
Obs.	61,201	38,953	68,390	68,315	68,370
Active	-.047*** (.008)	-.123*** (.010)	-.019*** (.004)	-.037*** (.006)	-.016*** (.004)
Obs.	46,690	29,984	52,710	52,652	52,689

Results: Probit (Stand/Walk)

LTPA	Overweig ht	Obese	Diabetes	High BP	Heart Disease
WRPA: Stand/Walk					
Daily	-.033*** (.004)	-.065*** (.005)	-.001 (.002)	-.011*** (.003)	-.002 (.002)
Obs.	116,350	71,834	130,444	130,348	130,390
Moderate	-.028*** (.004)	-.064*** (.005)	-.008*** (.002)	-.020*** (.003)	-.006*** (.002)
Obs.	116,350	71,834	130,444	130,348	130,390
Active	-.046*** (.005)	-.101*** (.007)	-.011*** (.002)	-.028*** (.003)	-.006*** (.002)
Obs.	85,208	52,886	95,695	95,618	95,659

Results: Probit (Lift Load)

LTPA	Overweig ht	Obese	Diabetes	High BP	Heart Disease
WRPA: Lift Light/ Heavy Load					
Daily	-.017*** (.005)	-.053*** (.006)	-.002 (.002)	-.009*** (0.003)	-.0006 (.001)
Obs.	91,955	55,497	99,416	99,297	99,394
Moderate	-.013*** (.005)	-.050*** (.006)	-.002 (.002)	-.013*** (.003)	-.002 (.001)
Obs.	91,955	55,497	99,416	99,297	99,394
Active	-.028*** (.006)	-.082*** (.007)	-.004** (.002)	-.019*** (.003)	-.002 (.002)
Obs.	68,510	41,481	74,152	74,076	74,138

Results: IV

LTPA/ WRPA	Overwei ght	Obese	Diabetes	High BP	Heart Disease
Daily	-.040 (.025)	-.034 (.032)	.015 (.010)	.020 (.016)	-.004 (.009)
Stand/Walk	-.026*** (.004)	-.053*** (.005)	-.017*** (.002)	-.020*** (.003)	-.013*** (.002)
Light Load	-.032*** (.005)	-.065*** (.006)	-.024*** (.002)	-.033*** (.003)	-.020*** (.002)
Heavy Load	-.007 (.006)	-.032*** (.008)	-.024*** (.002)	-.024*** (.004)	-.020*** (.002)
Observations	243,061	150,016	268,825	268,571	268,734
Hansen <i>J</i> Statistic	3.93 [0.14]	9.42 [0.01]	3.67 [0.16]	0.61 [0.74]	2.2 [0.33]
K-P rk LM	1646***	993***	1794***	1793***	1795***
Cragg-Donald	1314.7	784.15	1437.0	1436.4	1437.9
K-P rk Wald F	561.57	337.9	612.7	612.5	613.0

Results: IV cont.

LTPA/ WRPA	Overwei ght	Obese	Diabetes	High BP	Heart Disease
Moderate	-.032 (.020)	-.028 (.025)	.012 (.008)	.016 (.013)	-.003 (.008)
Stand/Walk	-.026*** (.004)	-.053*** (.005)	-.017*** (.002)	-.020*** (.003)	-.013*** (.002)
Light Load	-.032*** (.005)	-.065*** (.006)	-.024*** (.002)	-.033*** (.003)	-.020*** (.002)
Heavy Load	-.006 (.006)	-.033*** (.008)	-.023*** (.002)	-.024*** (.004)	-.020*** (.002)
Obs.	243,061	150,016	268,825	268,571	268,734
Hansen <i>J</i>	3.86	9.3	3.7	0.61	2.24
Statistic	[0.14]	[0.01]	[0.16]	[0.74]	[0.33]
K-P rk LM	2221***	1377***	2394***	2395***	2395***
Cragg-Donald	1856.7	1144.9	2004.4	2004.4	2005.8
K-P rk Wald F	768.0	475.1	827.7	827.8	828.2

Results: IV cont.

LTPA/ WRPA	Overwei ght	Obese	Diabetes	High BP	Heart Disease
Active	-.043** (.022)	-.065** (.027)	.016* (.009)	.013 (.013)	.002 (.008)
Stand/Walk	-.030*** (.005)	-.060*** (.006)	-.021*** (.002)	-.021*** (.003)	-.014*** (.002)
Light Load	-.036*** (.006)	-.070*** (.007)	-.028*** (.002)	-.033*** (.003)	-.021*** (.002)
Heavy Load	-.011 (.008)	-.045*** (.009)	-.027*** (.002)	-.027*** (.004)	-.021*** (.002)
Obs.	180,887	112,328	200,723	200,539	200,657
Hansen <i>J</i>	2.87	4.83	5.2	0.10	2.1
Statistic	[0.24]	[0.09]	[0.07]	[0.95]	[0.35]
K-P rk LM	2488***	1511***	2676***	2675***	2678***
Cragg-Donald	1983.4	1191.9	2143.9	2143.6	2146.4
K-P rk Wald F	871.4	525.2	936.4	936.3	937.4

Results: BP

LTPA/ WRPA	Overweight	Obese	Diabetes	High BP	Heart Disease
Daily	-.050* (.026)	-.057* (.030)	.005 (.007)	.010 (.013)	-.004 (.001)
Stand/ Walk	-.025*** (.004)	-.050*** (.005)	-.013*** (.002)	-.018*** (.003)	-.010*** (.001)
Light Load	-.031*** (.005)	-.060*** (.006)	-.019*** (.002)	-.030*** (.003)	-.014*** (.002)
Heavy Load	-.006 (.006)	-.028*** (.008)	-.020*** (.003)	-.022*** (.005)	-.017*** (.003)
Obs.	243,061	150,016	268,825	297,960	268,734
ρ	.04	-.02	-.06	-.08*	0.04

Results: BP cont.

LTPA/ WRPA	Overweig ht	Obese	Diabetes	High BP	Heart Disease
Moderate	-.029***	-.025	.007	.014	-.007
Stand/ Walk	(.020)	(.025)	(.007)	(.012)	(.007)
Light	-.027***	-.052***	-.013***	-.018***	-.009***
Load	(.004)	(.005)	(.002)	(.003)	(.001)
Heavy	-.033***	-.064***	-.019***	-.031***	-.014***
Load	(.005)	(.006)	(.002)	(.003)	(.002)
Obs.	-.008	-.031***	-.020***	-.022***	-.017***
ρ	(.006)	(.008)	(.003)	(.005)	(.003)
	243, 601	150,016	268,825	268,571	268,734
	0.04	-0.08*	-0.12***	-0.12***	-.005

Results: BP cont.

LTPA/ WRPA	Overweig ht	Obese	Diabetes	High BP	Heart Disease
Active	-.012 (.021)	-.053** (.027)	.008 (.007)	.012 (.011)	-.007 (.007)
Stand/ Walk	-.033*** (.005)	-.060*** (.006)	-.015*** (.002)	-.019*** (.003)	-.009*** (.002)
Light Load	-.040*** (.006)	-.069*** (.007)	-.022*** (.002)	-.031*** (.003)	-.015*** (.002)
Heavy Load	-.015** (.007)	-.043*** (.009)	-.022*** (.003)	-.025*** (.005)	-.017*** (.003)
Obs.	180,887	112,328	200,723	200,539	200,657
ρ	-0.05	-0.09*	-0.14***	-0.14***	-0.02

Results: IV (Sedentary)

LTPA	Overweight	Obese	Diabetes	High BP	Heart Disease
WRPA: Sedentary					
Daily	.044	.089	.032	.046	.037
	(.060)	(.079)	(.026)	(.038)	(.025)
Observations	55,044	35,043	61,489	61,428	61,470
Hansen <i>J</i>	3.09	6.83	3.1	1.4	1.9
Statistic	[0.21]	[0.03]	[0.21]	[0.50]	[0.38]
Moderate	.037	.072	.025	.037	.031
	(.050)	(.063)	(.021)	(.032)	(.020)
Observations	55,044	35,043	61,489	61,428	61,470
Hansen <i>J</i>	3.1	6.8	3.2	1.5	1.8
Statistic	[0.21]	[0.03]	[0.20]	[0.48]	[0.41]
Active	.031	.054	.050*	.039	.036
	(.055)	(.071)	(.026)	(.036)	(.024)
Observations	42,145	27,091	47,543	47,498	47,522
Hansen <i>J</i>	7.3	8.9	3.0	1.9	1.1
Statistic	[0.03]	[0.01]	[0.22]	[0.38]	[0.58]

Results: IV (Stand/Walk)

LTPA	Overweight	Obese	Diabetes	High BP	Heart Disease
WRPA: Stand/Walk					
Daily	-.064*	-.068	.008	.004	-.020
	(.038)	(.048)	(.015)	(.025)	(.015)
Obs.	104,875	64,722	117,515	117,431	117,464
Hansen <i>J</i>	0.7	3.4	1.8	0.8	0.9
Statistic	[0.69]	[0.18]	[0.42]	[0.67]	[0.65]
Moderate	-.054*	-.056	.006	.004	-.016
	(.031)	(.040)	(.013)	(.020)	(.012)
Obs.	104,875	64,722	117,515	117,431	117,464
Hansen <i>J</i>	0.6	3.3	1.8	0.8	0.9
Statistic	[0.74]	[0.19]	[0.40]	[0.68]	[0.65]
Active	-.072**	-.112***	-.008	-.002	-.004
	(.032)	(.040)	(.013)	(.021)	(.013)
Obs.	76,793	47,672	86,173	86,105	86,140
Hansen <i>J</i>	0.6	0.5	1.9	1.7	0.5
Statistic	[0.75]	[0.76]	[0.38]	[0.43]	[0.79]

Results: IV (Lift Load)

LTPA	Overweight	Obese	Diabetes	High BP	Heart Disease
WRPA: Lift Light/ Heavy Load					
Daily	-0.062 (.040)	-0.058 (.048)	.022* (.012)	.031 (.022)	-0.001 (.012)
Observations	83,142	50,251	89,821	89,712	89,800
Hansen <i>J</i>	1.5	1.3	2.0	9.0	3.4
Statistic	[0.48]	[0.53]	[0.36]	[0.01]	[0.19]
Moderate	-0.050 (.032)	-0.046 (.038)	.018* (.010)	.023 (.018)	-0.002 (.010)
Observations	83,142	50,251	89,821	89,712	89,800
Hansen <i>J</i>	1.5	1.3	1.9	9.2	3.3
Statistic	[0.46]	[0.52]	[0.39]	[0.01]	[0.19]
Active	-0.049 (.033)	-0.072* (.040)	.015 (.010)	.024 (.018)	-0.003 (.010)
Observations	61,949	37,565	67,007	66,936	66,995
Hansen <i>J</i>	0.5	0.5	2.3	7.1	3.5
Statistic	[0.78]	[0.78]	[0.31]	[0.03]	[0.17]

Results: BP (Sedentary)

LTPA	Overweight	Obese	Diabetes	High BP	Heart Disease
WRPA: Sedentary					
Daily	.057 (.057)	.065 (.078)	.013 (.021)	.030 (.038)	.018 (.027)
Observations	55,044	35,043	61,489	61,428	61,470
Estimated ρ	-0.16	-0.25*	-0.10	-0.15	-0.19
Moderate	.050 (.050)	.091 (.070)	.004 (.017)	.025 (.033)	.008 (.020)
Observations	55,044	35,043	61,489	61,428	61,470
Estimated ρ	-0.16*	-0.34***	-0.13	-0.16	-0.13
Active	.114** (.050)	.103 (.069)	.010 (.019)	.052 (.036)	-.014 (.022)
Observations	42,145	27,091	47,543	47,498	47,522
Estimated ρ	-0.28***	-0.39***	-0.17*	-0.27***	-0.03

Results: BP (Stand/Walk)

LTPA	Overweig ht	Obese	Diabetes	High BP	Heart Disease
WRPA: Stand/Walk					
Daily	-.087**	-.108**	.003	-.006	-.023
Observations	(.040)	(.048)	(.013)	(.022)	(.022)
Estimated ρ	104,875	64,722	117,515	117,43	117,464
	0.09	0.07	-0.04	1	0.16
				-0.02	
Moderate	-.056*	-.055	.002	.001	-.018
Observations	(.031)	(.038)	(.010)	(.020)	(.010)
Estimated ρ	104,875	64,722	117,515	117,43	117,464
	0.05	-0.02	-0.08	1	0.08
				-0.07	
Active	-.052*	-.121***	-.0005	-.004	-.012
Observations	(.010)	(.044)	(.011)	(.011)	(.011)
Estimated ρ	76,793	47,672	86,173	86,105	86,140
	0.01	0.03	-0.08	-0.09	0.03

Results: BP (Lift Load)

LTPA	Overweight	Obese	Diabetes	High BP	Heart Disease
WRPA: Lift Light/ Heavy Load					
Daily	-.082** (.041)	-.079* (.043)	.010 (.009)	.021 (.019)	-.002 (.010)
Observations	83,142	50,251	89,821	89,712	89,800
Estimated ρ	0.11*	0.05	-0.10	-0.13*	0.01
Moderate	-.030 (.032)	-.032 (.035)	.013* (.007)	.022 (.016)	-.004 (.009)
Observations	83,142	50,251	89,821	89,712	89,800
Estimated ρ	0.03	-0.04	-0.15**	-0.15**	0.01
Active	-.049 (.034)	-.076** (.034)	.006 (.007)	.013 (.016)	-.007 (.009)
Observations	61,949	37,565	67,007	66,936	66,995
Estimated ρ	0.04	-0.01	-0.10	-0.14**	0.04

Conclusions

- A negative association between LTPA and Obesity
- Negative associations between LTPA and chronic conditions (Diabetes, High BP and Heart Disease)
 - These results are largely consistent with previous studies in the literature
- WRPA exerts a negative effect on being overweight, obese and having chronic diseases among Canadians aged 18 to 75 years

Conclusions

- Once endogeneity of LTPA is accounted for, LTPA does not reduce the probability of obesity if WRPA is sedentary
- An active level of LTPA can cause a reduction in the probability of being overweight by some five to six percentage points and a reduction in obesity of 11 to 12 percentage points if some WRPA like standing or walking is in the mix
- Intensive WRPA seems to reduce the effect of LTPA

Conclusions

- Neither LTPA participation nor intensity causes a reduction in the probability of diabetes, high BP and heart disease
 - contrary to the results of Humphreys *et al.*
- **Key Policy Implications:**
 - Encourage active level of LTPA + promotion of physical activity in the workplace (or daily routine) to reduce overweight or obesity risks
 - Integrate physical activity into daily work lives, especially for those in sedentary occupations, to reduce the burden of preventable chronic diseases

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