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The independent role of deprivation in abdominal obesity beyond income poverty. A population-based household survey in Chinese adults

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ABSTRACT

Background Individual-level deprivation takes into account the non-monetary aspects of poverty that neither income poverty nor socio-economic factors could fully capture; however, it has rarely been considered in existing studies on social inequality in obesity. Therefore, we examined the associations of deprivation, beyond income poverty, with both general and abdominal obesity.

Methods A territory-wide two-stage stratified random sample of 2282 community-dwelling Hong Kong adults was surveyed via face-to-face household interviews between 2014 and 2015. Deprivation was assessed by a Deprivation Index specific to the Hong Kong population. General obesity was defined as body mass index (BMI) ≥ 25 kg/m^2, while abdominal obesity was defined as waist circumference (WC) ≥ 90 cm/80 cm for male/female. Multivariable binary logistic regressions were performed.

Results Deprivation was independently associated with abdominal obesity (odds ratios (OR) = 1.68; 95% confidence intervals (CI): 1.27–2.22); however, no significant association was found with general obesity (OR = 1.03; CI: 0.77–1.38). After additional adjustment for BMI, deprivation remained strongly associated with abdominal obesity (OR = 2.00; CI: 1.41–2.83); and after further adjustment for WC, deprivation had a marginal inverse association with general obesity (OR = 0.72; CI: 0.51–1.01).

Conclusions Deprivation is an important risk factor of abdominal obesity and plays a critical role in capturing the preferential abdominal fat deposition beyond income poverty.

Keywords abdominal obesity, deprivation, general obesity, Hong Kong, inequality, poverty

Introduction

Following the surge of global obesity prevalence over the past decades, a growing number of studies suggested a recent levelling-off of the obesity epidemic, especially in developed world regions.[1] While achievements in obesity control deserve recognition, a less evident levelling-off of obesity was observed in lower socio-economic groups,[1] suggesting that a low social position becomes an increasingly important social determinant of obesity as the increasing trend continues only in the socially disadvantaged.

It is apparent that social patterning of obesity is due not only to the differences in knowledge but also to the differences in material and social resources across socio-economic groups. A recent study on preventive obesity regulations showed that while policy makers and the advantaged usually have a 'wilful ignorance' that prefers strategies aiming

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to help the disadvantaged improve their health literacy, the disadvantaged, instead, urged for interventions to ameliorate those material constraints that hamper responses to health information and resource allocation on health investment.[2] The associated psychosocial stress also exacerbate obesity in the disadvantaged as it prompts fat storage especially in the abdominal cavity.[3] While most studies examined the disparity of obesity using monetary income and proxy socio-economic indicators,[4–7] these measures do not necessarily reflect the actual ability of individuals to acquire the material-based and social necessities of life.[8,9] To our best knowledge, few studies, if any, adopted the concept of context-specific individual-level deprivation of necessities when assessing social inequality in obesity in adults.

Apart from the socio-economic inequality in obesity control, different secular trends in general obesity and abdominal obesity were observed. Research in China and the USA indicated that the recent surge in abdominal obesity appeared to be independent of the corresponding change in general obesity.[10–13] Given that general and abdominal obesity are two distinct concepts approximately reflecting the total amount of body fat and the distribution of abdominal fat, respectively,[14] individuals could have the same total body fat but varying distribution patterns, possibly due to different exposures to socio-economic circumstances, lifestyle or other related social determinants. Hence, the associations of social disadvantages with abdominal obesity should be examined independent of general obesity, and vice versa.

We examined the associations of individual-level deprivation of necessities with both general and abdominal obesity beyond income poverty in community-dwelling adults in Hong Kong. In addition, we assessed the independent association of deprivation with general obesity for a given waist circumference (WC) and that with abdominal obesity for a given body mass index (BMI).

Methods

Study design and participants

Data were collected from a random sample of households in Hong Kong via face-to-face survey interviews from June 2014 to August 2015. A sample of 25 000 addresses and 200 segments was obtained from the Hong Kong Census and Statistics Department (C&SD), based on the C&SD frame of quarters. We adopted a two-stage stratified sampling, which first stratified records in the frame of quarters by geographical area (i.e. respondents' living areas by District Council) and then by type of quarters (i.e. public and private housing). Systemic replicate sampling technique with fixed sampling intervals and non-repetitive random numbers was used to select sampling units. First, a random sample of quarters was selected, and then all households residing in these quarters were randomly sampled. Second, a respondent aged 18 years or above whose birthday was coming up next within each household was recruited. Eventually, 4947 addresses were sampled with 3791 valid cases, of which 2282 household respondents were successfully enumerated with a response rate of 60.2%.

Weighting factors based on the distribution by age and sex of the mid-2014 Hong Kong population were applied (Supplementary Table S1). Three respondents without information on age or sex were excluded. Therefore, 2279 respondents were included in the final sample, of which 301 respondents were first randomly selected to confirm items for measuring deprivation and define its threshold value. Hence, the remaining 1978 respondents were included in the main analyses on the associations of poverty with obesity.

Measurements

Demographic and socio-economic factors

Demographic information on age, sex and marital status were collected. Age was divided into '18–39 years', '40–64 years' and '65 years or above', while marital status was categorized as married (including cohabitation) or unmarried (including never married, divorced, separated or widowed). Education was classified into 'primary or below', 'secondary' and 'tertiary'. Occupation status of economically active respondents' current or last jobs was categorized into three groups according to the assumed required skill levels as suggested by the International Labour Organization (i.e. Skill Level 1: Elementary occupations/Others; Skill Level 2: Clerical support workers/Service and sales workers/Craft and related workers/Plant and machine operators and assemblers; and Skill Levels 3 or 4: Managers and administrators/Professionals/Associate professionals).[15] The occupation categories also included students and persons looking after family/home since they represented the respondents' economic activity.

Multi-dimensional poverty

In addition to socio-economic factors, both income poverty and deprivation were included in the analysis as the main independent variables. Income poverty was measured by equivalised household income, which was a relative income concept defined in relation to the standards that exist elsewhere in a society.[16] Equivalised household income was derived by dividing household income by the square root of the number of people in the household to allow for economies of scale when comparing households of different sizes.[17] Subjects receiving less than half of the median

equivalised household monthly income in this sample (i.e. HK$6 059.2) were classified as 'Poor'. As for deprivation, we followed Townsend's theory of relative deprivation defined as a lack of command over resources covering material and social necessities.[18] To construct a Deprivation Index (DI), the randomly selected 301 respondents were asked whether they perceived a list of material-based and social items as necessities of the majority of the Hong Kong population (Supplementary Table S2). The resulting 21-item DI was used to assess if respondents could not afford the list of material and social necessities.[19] As the mean deprivation scores were high in the lowest income decile (2.66) but dropped drastically in the second and third deciles (1.55 and 1.32, respectively), respondents with an additive score of two or above were considered 'Deprived' (Supplementary Table S3).

Lifestyle factors

Smoking status was divided into non-smoker and past/current smoker, while alcohol drinking was categorized as non-risky drinker and risky drinker using Alcohol Use Disorders Identification Test-Consumption (AUDIT-C),[20] which was derived from the first three questions of the AUDIT instrument. Subjects with a score of five or above out of 12 was identified as potentially risky drinkers.[21] Physical activity was assessed by the International Physical Activity Questionnaire short form.[22] Three levels of physical activity (active, minimally active and inactive) were used for classification. Daily sleep duration was categorized into four levels (i.e. <4 h, 5–6, 7–8 and more than 8).

Obesity measures

Both general and abdominal obesity were included as outcomes. Height, weight and WC of respondents were measured by trained interviewers. General obesity was defined as BMI $\geq$ 25 kg/m^2 based on the Asian cut-off suggested by the World Health Organization,[23] while abdominal obesity was defined as WC $\geq$ 90 cm for male and WC $\geq$ 80 cm for female according to the guidelines of the International Diabetes Federation,[24] since WC was found to be an approximate indicator of abdominal obesity and visceral fat in Chinese adults.[25] An alternative measure of abdominal obesity using waist-to-height ratio (WHtR), which defined respondents with a WHtR > 0.5 to be abdominally obese, was also adopted for comparison, since it takes into account height in the measurement and is increasingly recognized as a more useful global screening tool over WC in predicting cardio-metabolic diseases.[26,27]

Statistical analysis

Sample characteristics of the 1978 respondents included in the main analyses were presented as frequencies with percentages, and were further stratified by deprivation. Univariate analyses on the crude associations of poverty measures and potential confounders with both general and abdominal obesity were conducted. Multivariable binary logistic regressions were performed to separately examine the associations of deprivation with general obesity and abdominal obesity. In adjusted model 1, income poverty, demographic and socio-economic characteristics were included, while in adjusted model 2, deprivation was additionally adjusted to assess the changes in associations of income poverty and socio-economic factors. Moreover, two comparison models were constructed. Comparison model 1 explored whether lifestyle factors had any important effects on the association of deprivation with obesity, while comparison model 2 assessed the independent association of deprivation with abdominal obesity by adjusting for BMI, and that with general obesity by adjusting for WC. A sensitivity analysis was conducted by replicating the analyses using WHtR as the outcome measure. The analyses were also replicated using an alternative cut-off deprivation score at one to ensure the robustness of results. Multiple imputation by chained equations (MICE) was adopted for the multivariable analyses to estimate a set of plausible values for the missing data based on the distribution of the observed data.[28] The statistical package Stata version 14 was employed. All statistical tests were two-tailed with a significance level of $P < 0.05$.

Results

Descriptive statistics

Weighted descriptive characteristics of respondents were reported in Table 1. Regarding multi-dimensional poverty, 14.4% were income poor and 16.9% were deprived. As for obesity, 29.2% were generally obese, while 31.6% were abdominally obese. Descriptive characteristics stratified by deprivation were also reported in Table 1.

Associations with general obesity

The crude and adjusted odds ratios (OR), with their corresponding 95% confidence intervals (CI) and *P* values, of the associations with general obesity were presented in Table 2. As shown in adjusted models 1 and 2, neither income poverty nor deprivation was associated with general obesity after adjustments for demographic and socio-economic factors. Additional adjustments for lifestyle factors in comparison

Table 1 Weighted characteristics of subjects ($N = 1978$)[a]

	Total sample Column (%)	*Deprived Column (%)*	*Non-deprived Column (%)*
Poverty measures			
Deprivation			
Non-deprived	83.1	NA	NA
Deprived	16.9	NA	NA
Income poverty			
Non-poor	85.6	60.3	90.6
Poor	14.4	39.7	9.4
Socio-demographic factors			
Age (years)			
18–39	36.6	19.5	40.2
40–64	46.2	55.1	44.4
65 or above	17.1	25.4	15.4
Sex			
Male	45.3	38.6	46.6
Female	54.7	61.4	53.4
Marital status			
Single/Divorced/Separated/Widowed	37.6	38.6	37.4
Married/Cohabit	62.4	61.4	62.6
Education			
Primary or below	25.1	40.6	21.9
Secondary	55.1	52.2	55.6
Tertiary	19.9	7.2	22.5
Occupation			
Skill levels 3 or 4	14.3	4.4	16.3
Skill level 2	37.9	31.2	39.2
Skill level 1	18.7	29.3	16.6
Student	5.6	3.4	6.0
Looking after family/home	23.5	31.8	21.8
Lifestyle factors			
Physical activity			
Inactive	76.6	80.8	75.7
Minimally active	12.8	11.1	13.2
HEPA active	10.6	8.1	11.1
Smoking			
Non smoker	80.7	76.1	81.7
Past smoker/current smoker	19.3	23.9	18.3
Alcohol drinking			
Non-risky drinker	95.8	95.5	95.9
Risky drinker	4.2	4.5	4.1
Sleep duration			
<4 h per day	3.8	8.4	2.9
5–6 h per day	36.5	38.3	36.1
7–8 h per day	44.1	37.1	45.5
More than 8 h per day	15.5	16.2	15.4
Obesity measures			
General obesity			
Underweight/Normal/Overweight	70.8	67.9	71.2
Obesity	29.2	32.1	28.8

Continued

Table 1 Continued

	Total sample Column (%)	*Deprived Column (%)*	*Non-deprived Column (%)*
Abdominal obesity			
Normal	68.4	54.0	71.0
Abdominally obese	31.6	46.0	29.0

[a]Number of responses may vary due to missing data.

model 1 did not significantly change the associations, whereas after further adjustments for WC in comparison model 2, being deprived became marginally inversely associated with general obesity (OR = 0.72; CI: 0.51–1.01).

Associations with abdominal obesity

The associations with abdominal obesity, in terms of WC, were reported in Table 3. After adjustments for demographic and socio-economic factors in adjusted model 1, the association of income poverty with abdominal obesity attenuated to non-significance level (OR = 1.10; CI: 0.79–1.53). When deprivation was included in adjusted model 2, the adjusted OR of income poverty further attenuated (OR = 0.93; CI: 0.66–1.31), while deprivation was significantly associated with abdominal obesity (OR = 1.68; CI: 1.27–2.22). Additional adjustment for lifestyle factors in comparison model 1 showed negligible change. In comparison model 2, controlling for BMI, being deprived remained strongly associated with abdominal obesity (OR = 2.00; CI: 1.41–2.83). The findings remained consistent when WHtR was adopted as the alternative measure of abdominal obesity (Supplementary Table S4).

The general patterns remained unchanged when the analyses were replicated using an alternative cut-off deprivation score (Supplementary Tables S5–S7).

Discussion

Main finding of this study

Our study showed that neither income poverty nor deprivation was associated with general obesity while deprivation was stronger than income poverty in predicting abdominal obesity in the community-dwelling adults in Hong Kong. Non-dietary lifestyle factors did not significantly change the associations between deprivation and obesity. Given similar amount of total body fat, as approximately reflected by BMI due to their strong relationship,[29] being deprived remained strongly associated with abdominal obesity (i.e. having a higher proportion of fat distributed in the abdominal cavity). Our findings suggested a preferential abdominal fat deposition in the deprived.

What is already known on this topic

Although socio-economic factors and income poverty are straight-forward and easy to interpret, they omit the non-monetary aspects of the multi-dimensional poverty. Deprivation, on the other hand, is a distinct albeit related poverty measure that reflects the actual ability of individuals to acquire necessities that are customary to a given society.[30] Recent reviews on deprivation and poverty in Hong Kong also suggested a low overlap between income poverty and deprivation, indicating that both measures play distinct roles in identifying most vulnerable social groups.[31,32] Therefore, deprivation should not simply be considered as a hardship stemmed from income poverty but also an independent social indicator. Moreover, the strong and independent effect of deprivation on abdominal obesity beyond and above income poverty observed in the present study echoed findings in previous studies showing that deprivation may serve as an important dimension of social determinants of health that neither income nor socio-economic factors could address.[19,33]

What this study adds

This is the first study to adopt individual-level deprivation as a social determinant of obesity in adults. Also, while social inequalities in obesity in favour of the better-off have generally been observed in developed regions,[4,34] few studies revealed differential associations of social disadvantages with general and abdominal obesity[35,36] as observed in the present study. One study found an independent inverse association of education attainment with WC but not with BMI among the Portuguese respondents,[35] whereas another study showed that the associations of education level with BMI may not necessarily be consistent with that with waist circumstance.[36] Therefore, our findings lend further support to

Table 2 Binary logistic regression on general obesity

	General obesity, BMI ≥ 25 kg/m²									
	Univariate model		*Adjusted model 1*		*Adjusted model 2*		*Comparison model 1*		*Comparison model 2*	
	OR (95% CI)	P-*value*	*AOR (95% CI)*	P-*value*	*AOR (95% CI)*	P-*value*	*AOR (95% CI)*	P-*value*	*AOR (95% CI)*	P-*value*
Deprivation										
Non-deprived	1				1		1		1	
Deprived	1.18 (0.91–1.54)	0.212			1.03 (0.77–1.38)	0.824	1.03 (0.76–1.38)	0.868	0.72 (0.51–1.01)	0.056
Income poverty										
Non-poor	1		1		1		1		1	
Poor	1.24 (0.93–1.67)	0.143	0.97 (0.70–1.35)	0.854	0.96 (0.68–1.36)	0.815	0.97 (0.68–1.37)	0.847	1.01 (0.69–1.48)	0.978
Age (years)										
18–39	1		1		1		1		1	
40–64	1.72 (1.30–2.26)	<0.001	1.41 (1.02–1.93)	0.036	1.40 (1.02–1.93)	0.037	1.43 (1.04–1.98)	0.029	1.34 (0.93–1.95)	0.117
65 or above	2.35 (1.72–3.19)	<0.001	1.77 (1.20–2.61)	0.004	1.77 (1.21–2.61)	0.004	1.84 (1.24–2.75)	0.003	1.02 (0.65–1.62)	0.918
Sex										
Male	1		1		1		1		1	
Female	0.77 (0.62–0.95)	0.016	0.62 (0.48–0.81)	<0.001	0.62 (0.48–0.81)	<0.001	0.58 (0.44–0.77)	<0.001	0.31 (0.22–0.43)	<0.001
Marital status										
Single/Divorced/Separated/Widowed	1		1		1		1		1	
Married/Cohabit	1.44 (1.15–1.80)	0.002	1.21 (0.94–1.56)	0.145	1.21 (0.94–1.56)	0.145	1.22 (0.94–1.58)	0.133	1.08 (0.80–1.45)	0.624
Education										
Tertiary	1		1		1		1		1	
Secondary	1.38 (0.98–1.94)	0.065	1.03 (0.70–1.51)	0.888	1.03 (0.70–1.51)	0.894	1.04 (0.71–1.53)	0.849	1.01 (0.63–1.62)	0.958
Primary or below	2.12 (1.47–3.06)	<0.001	1.32 (0.84–2.07)	0.221	1.32 (0.84–2.07)	0.228	1.31 (0.83–2.07)	0.238	1.03 (0.60–1.76)	0.920
Occupation										
Skill levels 3 or 4	1		1		1		1		1	
Skill level 2	1.01 (0.69–1.48)	0.954	0.92 (0.62–1.37)	0.692	0.92 (0.62–1.37)	0.687	0.92 (0.62–1.36)	0.670	1.20 (0.72–1.99)	0.490
Skill level 1	1.27 (0.85–1.89)	0.237	1.04 (0.68–1.58)	0.870	1.03 (0.68–1.57)	0.883	1.03 (0.68–1.57)	0.883	1.12 (0.65–1.93)	0.685
Student	0.48 (0.24–0.95)	0.034	0.71 (0.34–1.46)	0.348	0.70 (0.34–1.46)	0.345	0.70 (0.34–1.47)	0.348	0.80 (0.37–1.75)	0.582
Looking after family/home	1.34 (0.90–1.99)	0.151	1.46 (0.94–2.28)	0.092	1.46 (0.94–2.28)	0.095	1.47 (0.94–2.29)	0.092	1.49 (0.86–2.60)	0.158
Physical activity										
HEPA active	1						1			
Minimally active	1.11 (0.72–1.73)	0.635					1.07 (0.68–1.67)	0.783		
Inactive	1.21 (0.86–1.71)	0.281					1.30 (0.91–1.87)	0.153		
Smoking										
Non smoker	1						1			
Past smoker/current smoker	1.09 (0.84–1.43)	0.517					0.83 (0.61–1.14)	0.252		

Alcohol drinking						
Non-risky drinker	1			1		
Risky drinker	0.98 (0.55–1.74)	0.938		1.00 (0.54–1.85)	0.991	
Sleep duration						
<4 h per day	1			1		
5–6 h per day	0.93 (0.52–1.64)	0.793		0.99 (0.55–1.77)	0.961	
7–8 h per day	0.80 (0.45–1.41)	0.443		0.91 (0.51–1.63)	0.749	
More than 8 h per day	0.82 (0.44–1.55)	0.542		0.96 (0.50–1.86)	0.912	
Abdominal obesity						
Non-abdominally obese	1				1	
Abdominally obese	11.85 (9.24–15.20)	<0.001			17.06 (12.71–22.90)	<0.001

the differential social patterning of general and abdominal obesity.

Referring to the literature on health inequality, three potential mechanisms, namely, behavioural pathway, materialist pathway and psychosocial pathway, have been commonly postulated.[37] As inclusion of behavioural factors did not significantly attenuate the association between deprivation and abdominal obesity, material and psychosocial factors may be potential explanations for the observed social inequality in abdominal obesity but not in general obesity.

The social inequality in abdominal obesity could be attributed to the graded association between social disadvantages and access to material necessities such as food, amenities, services and properties.[37] In particular, unaffordability of fruits and vegetables, as captured by the DI, may plausibly be a major contributor of the inequality in abdominal obesity, provided that the only consistent evidence of dietary inequalities suggested by a recent systemic review was a lower consumption of fruits and vegetables in the disadvantaged.[38] In light of the surge in prices of fruits and vegetables at an average rate of 2–3% annually in the past two decades in high-income and emerging economies,[39] fruits and vegetables became more costly compared to less healthy options, making them less affordable by the deprived. Deprivation of fruits and vegetables provided a possible clue to the higher risk of abdominal obesity rather than general obesity in the deprived since a previous multinational prospective cohort study found that a lower consumption of fruits and vegetables was associated with a greater gain in WC for a given BMI.[40] The beneficial effect on waist change but not on weight change may be due to a lower glycaemic response induced by a higher fruit and vegetable consumption, since visceral fat is more vulnerable than subcutaneous fat to high insulin responses stimulated by foods with high glycaemic index.[41]

While the measurement of deprivation mainly took material and social circumstances into account, it is difficult to disentangle the material and psychosocial effects on the inequalities in abdominal obesity from one another.[37] Stress associated with deprivation may exert adverse effects, possibly through the allostatic load, on various physiological systems.[42] Notably, cortisol, a stress-related hormone, has played a pivotal role in the preferential abdominal fat deposition,[43,44] as hypercortisolemia leads to an expansion of visceral fat depots and a depletion of peripheral subcutaneous depots.[45] Moreover, the depot-specific effect is related to a higher density of glucocorticoid receptors in the visceral adipose tissues, which promotes abdominal obesity when stress-related cortisol is in excess.[46] Taking the neuroendocrine mechanisms of stress-related hormones on abdominal

Table 3 Binary logistic regression on abdominal obesity

	Abdominal obesity, WC ≥ 90 cm for male and WC ≥ 80 cm for female									
	Univariate model OR (95% CI)	P-*value*	*Adjusted model 1* AOR (95% CI)	P-*value*	*Adjusted model 2* AOR (95% CI)	P-*value*	*Comparison model 1* AOR (95% CI)	P-*value*	*Comparison model 2* AOR (95% CI)	P-*value*
Deprivation										
Non-deprived	1				1		1		1	
Deprived	2.10 (1.64–2.70)	<0.001			1.68 (1.27–2.22)	<0.001	1.67 (1.25–2.23)	<0.001	2.00 (1.41–2.83)	<0.001
Income poverty										
Non-poor	1		1		1		1		1	
Poor	1.74 (1.31–2.31)	<0.001	1.10 (0.79–1.53)	0.588	0.93 (0.66–1.31)	0.676	0.93 (0.65–1.32)	0.678	0.94 (0.63–1.40)	0.748
Age (years)										
18–39	1		1		1		1		1	
40–64	1.72 (1.31–2.26)	<0.001	1.35 (0.98–1.86)	0.068	1.30 (0.94–1.80)	0.107	1.34 (0.96–1.86)	0.085	1.10 (0.76–1.60)	0.610
65 or above	4.10 (3.03–5.55)	<0.001	2.76 (1.88–4.07)	<0.001	2.81 (1.91–4.15)	<0.001	2.86 (1.90–4.29)	<0.001	2.73 (1.69–4.41)	<0.001
Sex										
Male	1		1		1		1		1	
Female	2.18 (1.75–2.73)	<0.001	1.89 (1.44–2.48)	<0.001	1.89 (1.44–2.48)	<0.001	1.69 (1.25–2.29)	0.001	3.60 (2.55–5.07)	<0.001
Marital status										
Single/Divorced/Separated/Widowed	1		1		1		1		1	
Married/Cohabit	1.33 (1.07–1.66)	0.010	1.30 (0.99–1.70)	0.054	1.32 (1.00–1.72)	0.047	1.33 (1.01–1.76)	0.041	1.29 (0.94–1.78)	0.114
Education										
Tertiary	1		1		1		1		1	
Secondary	1.44 (1.02–2.03)	0.039	1.06 (0.72–1.57)	0.762	1.04 (0.70–1.54)	0.851	1.04 (0.70–1.54)	0.859	1.02 (0.65–1.60)	0.927
Primary or below	3.72 (2.60–5.34)	<0.001	1.71 (1.10–2.68)	0.018	1.65 (1.05–2.57)	0.028	1.61 (1.03–2.53)	0.038	1.61 (0.95–2.72)	0.079
Occupation										
Skill levels 3 or 4	1		1		1		1		1	
Skill level 2	0.93 (0.64–1.36)	0.715	0.70 (0.47–1.05)	0.085	0.68 (0.45–1.02)	0.063	0.68 (0.45–1.02)	0.064	0.61 (0.38–1.00)	0.048
Skill level 1	1.79 (1.21–2.65)	0.003	1.02 (0.66–1.56)	0.938	0.96 (0.62–1.47)	0.838	0.95 (0.62–1.47)	0.820	0.93 (0.55–1.58)	0.785
Student	0.53 (0.27–1.05)	0.069	0.72 (0.34–1.51)	0.384	0.69 (0.33–1.45)	0.323	0.68 (0.32–1.42)	0.301	0.74 (0.34–1.65)	0.466
Looking after family/home	2.68 (1.81–3.98)	<0.001	1.25 (0.80–1.96)	0.331	1.18 (0.75–1.86)	0.470	1.19 (0.75–1.88)	0.469	0.97 (0.57–1.65)	0.904
Physical activity										
HEPA active	1						1			
Minimally active	1.81 (1.18–2.77)	0.007					1.40 (0.89–2.20)	0.151		
Inactive	1.49 (1.06–2.09)	0.021					1.56 (1.07–2.26)	0.019		
Smoking										
Non smoker	1						1			
Past smoker/current smoker	0.63 (0.48–0.84)	0.001					0.83 (0.58–1.18)	0.290		

Alcohol drinking						
Non-risky drinker	1			1		
Risky drinker	0.34 (0.17–0.69)	0.003		0.55 (0.26–1.18)	0.124	
Sleep duration						
<4 h per day	1			1		
5–6 h per day	0.58 (0.33–1.02)	0.060		0.82 (0.44–1.52)	0.520	
7–8 h per day	0.43 (0.25–0.76)	0.004		0.76 (0.41–1.40)	0.372	
More than 8 h per day	0.49 (0.26–0.89)	0.020		0.82 (0.42–1.60)	0.560	
General obesity						
Non-generally obese	1					1
Generally obese	11.85 (9.24–15.20)	<0.001				17.11 (12.70–23.05) <0.001

obesity into account, the psychosocial pathway may provide a plausible explanation to our findings of a higher risk of abdominal obesity for a given BMI but a lower risk of general obesity for a given WC in the deprived.

As abdominal obesity is particularly associated with metabolic risk factors, cardiovascular events, and mortality beyond general obesity,[47,48] a higher risk of abdominal obesity in the deprived would not only mean a greater cardiometabolic disease burden, but also impose tremendous burden on social welfare and health care systems in the public sector, which the deprived tend to rely on. Early interventions on abdominal obesity control should be targeted to the deprived in addition to the low income groups. Apart from conventional endowment policies and health education programmes on healthy lifestyle for obesity control, mechanisms and policies to increase the affordability of healthy foods, especially fruits and vegetables, as well as promotion of stress management may be particularly important in controlling abdominal obesity in the deprived in Hong Kong.

Limitations of this study

Due to the cross-sectional nature of this study, no temporal sequence could be established and little change in social circumstances of respondents is assumed. Also, residual confounding including genetic differences may exist. Moreover, we did not include dietary energy intake for adjustment as our study focused on the social patterning of obesity; i.e. lifestyle factors should not be treated as confounders since they are also patterned by socioeconomic circumstances. Additional adjustments for lifestyle factors were only used for comparison purpose in this study. Furthermore, there are potential limitations of WC and BMI in reflecting abdominal fat and total fat, respectively. WC may not fully represent the amount of visceral adipose tissues since abdominal fat stored subcutaneously may also be reflected by WC;[26] nonetheless, WC was found to be an approximate indicator of abdominal obesity and a moderate predictor of visceral fat in Chinese adults.[25] Consistent results shown in the sensitivity analysis using WHtR as the alternative measure of abdominal obesity also ensure the robustness of our findings. As for BMI, it cannot effectively disentangle fat mass from lean mass, which may create bias across age and sex;[29] hence, age groups and sex were adjusted in the analyses.

Conclusions

Deprivation, which reflects the lack of command over resources covering material and social necessities, captures a preferential abdominal fat deposition beyond income poverty. Obesity interventions should move beyond general

population strategy and target socially deprived individuals, especially since abdominal obesity is a stronger risk factor than general obesity of subsequent cardio-metabolic diseases. Longitudinal studies are warranted to further delineate the temporal relationship between deprivation and abdominal obesity, and the potential mediating roles of different mechanistic pathways in the association.

Supplementary data

Supplementary data are available at the *Journal of Public Health* online.

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Ethics approval

The study has been approved by the Survey and Behavioural Research Ethics Committee of the Chinese University of Hong Kong in June 2012. Informed consents were obtained from each of our participants.

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