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Rural-urban differences in the association between disability and body mass index among the oldest-old in China

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ABSTRACT

Introduction: The issue of disability prevention is considered as a priority for research in geriatrics in modern society, especially for the oldest-old. There are many evidences certificated that obesity is associated with disability in developed countries. However, few studies pay attention to relationship between them in developing countries. Furthermore, it is also unknown whether the association is similar among the oldest-old in rural and urban areas. The purpose of this study is to explore rural-urban differences in the association between disability and BMI among the oldest-old in China.

Methods: 4076 seniors (80+) were included from the 2014 wave of Chinese Longitudinal Healthy Study. Disability, body mass index and other information including socio-demographic variables, health behavior conditions and health status were collected. Logistic regression analysis was employed to examine the association.

Results: Of 4076 respondents, 1817 (44.6%) were urban elderly. Overall, 26.6% of the participants had disability, and 31.8% for urban, 22.4% for rural. After controlling for other variables, the significant association between BMI and disability was found for urban oldest seniors, but not for rural ones. Age, living arrangement, Non-communicable disease and annual physical examination were important determinants related to disability.

Conclusions: The association between BMI and disability differed according to residence. Both overweight and underweight were red flags of disability among Chines seniors (80+) in urban areas. Therefore, proper weight management is important for preventing disability among urban oldest-old. Additionally, annual physical examination, prevention and control of chronic diseases should be recommended to all of the oldest-old.

1. Introduction

The World Health Organization (WHO) reported that approximately 15% of the global population lived with disability, of whom 2–4% suffered serious difficulties in functioning (Organization, 2018). Disability is related to increased healthcare costs (Anderson, Wiener, Khatutsky, & Armour, 2013), heavy burden for caregivers and decreased quality of life (Organization WH, 2011). As a result of population ageing, improvement in medical technology, and wide spread of chronic disease, the proportion of disability will be on the rise (Zeng, Feng, Hesketh, Christensen, & Vaupel, 2017). Consequently, disability prevention is considered as a priority for global research in geriatrics (Ferrucci et al., 2004). In China, the number of disabled elderly was 40,630,000 in 2015, accounting for 18.3%. Among them, seniors (80+) is often accompanied by declining functions of organs and suffering from one or more diseases, leading to high risk of disability. In addition, because of diminishing supportive functions of family and insufficient economic resources, social care is a matter of cardinal significance (Jiang & Wei, 2015). Therefore, it is vital to identify determinants among the oldest old for control and prevention of disability. Several previous studies have identified influential factors for disability, such as social-demographic variables (age Nagarkar & Kashikar, 2017), living arrangement (Li, Zhang, & Liang, 2009; Wang, Chen, Pan, Jing, & Liu, 2013), residence (Liu et al., 2018), ethnicity (Luo, Lyu, & Yin, 2017), health behavior (Yin, Shi, & Kraus, 2014) (smoking, drinking, physical activities) and health status (NCDChen, Fang, & Mao, 2015; Su, Ding, & Zhang, 2016), feeling of loneliness (Nagarkar & Kashikar, 2017; Perissinotto, Stijacic Cenzer, & Covinsky, 2012).

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Meanwhile, the prevalence of obesity is increasing in developed and developing countries now and in the future (Ng, Fleming, & Robinson, 2014; Swinburn, Sacks, & Hall, 2011). Body mass index (BMI) is usually used as an indicator of general obesity status (Yin et al., 2014). There are many evidences certificate that obesity is associated with disability in developed countries (Alley & Chang, 2007; Backholer et al. 2012a; Launer, Harris, Rumpel, & Madans, 1994; Nam, Kuo, Markides, & Al Snih, 2012; Wee, Huskey, & Ngo, 2011). However, few studies pay attention to relationship between them in developing countries and among the oldest-old. Furthermore, to our knowledge, there is no study that focuses on whether the association between disability and body mass index among the Chinese oldest-old is similar between rural and urban area in China where there are great disparity existing in healthcare resources and socioeconomic status (Gu, Zhang, & Zeng, 2009; Shi, 1993; Zhang et al., 2017).

Given disability is common among the Chinese oldest-old and no study on rural-urban differences in relationship between disability and BMI, the purpose of our study is to investigate the association between them varies by urban/rural groups among Chinese seniors aged 80 or above with a relatively large sample.

2. Methods

2.1. Study sample

We used data from the most recent wave of the Chinese Longitudinal Healthy Longevity Survey (CLHLS) in 2014. The CLHLS was the first and ongoing national survey with largest number of the oldest-old in China, which was conducted in half of the cities/counties in 23 provinces throughout China. It was initiated in 1998 and then followed in 2000, 2002, 2005, 2008, 2011, and 2014. The interviews were conducted by trained interviewers to ensure the reliability and validity of the data, which was proved to be with good quality (Hou, Ping, & Yang, 2018; Zhang et al., 2017). All centenarians (ages 100+) were adopted into the sample, one nearby nonagenarian (ages 90–99) and octogenarian (ages 80–89) of pre-designed residence and age were randomly interviewed, which ensured the adequate number of randomly selected urban and rural oldest seniors over 80 years in China. The Ethical Committee of Peking University approved the study protocol. Participants were informed about the aim of survey, selection criterion of the sample, and assurance that the information was only used for research. Furthermore, the proxy consent procedure was given for those participants who were considered cognitively impaired. All participants gave written informed consent before inclusion in the study.

2.2. Measurements

2.2.1. Disability

Activity of daily living (ADL) are considered as one of common ways to define disability (Barberger-Gateau, Rainville, Letenneur, & Dartigues, 2000; Su et al., 2016). ADL disability was measured by Katz Activity of Daily Living Scale (Alexandre Tda et al., 2012; Chou & Leung, 2008; Ge et al., 2017; Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963), which included the following six items: feeding, dressing, bathing, toileting, walking inside, bladder and bowel control. Each item had two response choices: “dependent” and “independent”. ADL disability was dichotomized as no difficulty and having difficulty. If any answer was “dependent”, the elderly was categorized as ADL disability which means needing equipment or human help to complete the above task, otherwise, the seniors were defined as non-disabled ones. The Chinese version scale was proven to be of good validity and reliability (Chen et al., 2015).

2.2.2. Body mass index

Body mass index (BMI) was calculated using weight (kg) divided by height (m^2). In order to do further analysis, BMI status was categorized into four groups, including obese (BMI > 30), overweight ($25 \leq BMI \leq 30$), normal ($18.5 \leq BMI \leq 25$) and underweight (BMI < 18.5).

2.2.3. Covariates

Covariates included a variety of social-demographic variables (age, education level, marital status, economical status, ethnicity, gender, living arrangement), health behavior variables (annual physical examination, smoking, drinking, physical activity), and health status variables (feeling of loneliness, non-communicable chronic disease). Education status was categorized as “illiterate” if the elderly had no education, and “literate” if the sample had received any education. Marital status was defined as “couple” if the elderly was currently married, and as “single” if they were never married, widowed, or divorced. Economical status was divided into three types, which are related to Q3 - Q1. Living arrangement was defined as “living alone” and “living with children or others”. Feeling of loneliness was assessed by the question, “Do you feel lonely?” We dichotomized the answer into two categories: “yes” If the answer was always, often, sometimes, and “no” if the response was rarely or never. Non-communicable chronic disease (NCD) was divided into three groups, such as none, one, and more than one.

2.3. Statistical analysis

All statistical analyses were conducted individually on urban and rural subgroups. The statistical package SPSS20.0 was employed to analyze the data. Chi-square test was performed to examine differences in independent variables mentioned above between urban and rural oldest-old. Logistic regression was applied to assess the association of disability and BMI in the oldest seniors, and to identify the explanatory factors in the urban and rural seniors respectively. All reported CIs were calculated at the 95% level. Statistical significance was set at the 5% level.

Four models were adopted to identify how different covariates related to the association. Firstly, model 1 was run without adjustment. Next, three nested models were used: included covariates for sociodemographics (model 2), then included additionally “health behavior” variables (model 3), and final model further included “health status” variables (model 4).

3. Results

Among 7192 subjects in the 2014 wave of CLHLS, 4738 were aged 80 years old and above. We eliminated participants with missing data on important variables, including height and weight. Thus, the final sample size was 4076 that included 1817 urban seniors and 2259 rural ones.

Table 1 presents the characteristics of total sample and the differences of disability between urban and rural subgroups. For all oldest-old, age, education, marital status, ethnicity, gender, residence, living arrangement, annual physical examination, drinking, feeling of loneliness, NCD and BMI were associated with disability. The differences among urban and rural subgroup were also described respectively. For urban seniors, all variables above were related to disability except ethnicity. For rural ones, the statistical sense did not exist for economic status, physical activity, NCD and BMI.

Table 2 reports the association between disability and BMI among oldest seniors. Results from model 1 identified that ADL disability among the oldest old who are underweight or overweight was significantly higher than that among the seniors (80+) who are normal. Model 2 indicated that when controlling for other variables, ADL disability was statistically higher among seniors who are either underweight (OR = 1.206, 95CI 1.009–1.441, P = 0.039) or overweight (OR = 1.593, 95CI 1.261–2.013, P = 0.000).

Table 1
Description of disability by urban-rural residence among seniors aged 80 and older in China, CLHLS 2014.

	Total(N = 4076)		Urban(N = 1817)		Rural(N = 2259)	
	ADL disability	Others	ADL disability	Others	ADL disability	Others
N(%)	1083(26.6)	2993(73.4)	578(31.8)	1239(68.2)	505(22.4)	1754(77.6)
Socio-demographics						
Age						
80-89	315(29.1)	1707(57.0) ***	180(31.1)	744(60) ***	135(26.7)	963(54.9) ***
90-99	464(42.8)	941(31.4)	265(45.8)	390(31.5)	199(39.4)	551(31.4)
100+	304(28.1)	345(11.5)	133(23)	105(8.5)	171(33.9)	240(13.7)
Education						
Illiterate	764(70.5)	1904(63.6) ***	362(62.6)	697(56.3) *	402(79.6)	1207(68.8) ***
Literate	319(29.5)	1089(36.4)	216(37.4)	542(43.7)	103(20.4)	547(31.2)
Marital status						
Couple	214(19.8)	894(29.9) ***	123(21.3)	387(31.2) ***	91(18.0)	507(28.9) ***
Single	869(80.2)	2099(70.1)	455(78.7)	852(68.8)	414(82.0)	1247(71.1)
Economical status [a]						
Q3	195(18)	503(16.8)	135(23.4)	264(21.3)	60(11.9)	239(13.6)
Q2	757(69.9)	2168(72.4)	379(65.6)	857(69.2)	378(74.9)	1311(74.7)
Q1	131(12.1)	322(10.8)	64(11.1)	118(9.5)	67(13.3)	204(11.6)
Ethnicity						
Han	1039(95.9)	2742(91.6) ***	552(95.5)	1172(94.6)	487(96.4)	1570(89.5) ***
Minority	44(4.1)	251(8.4)	26(4.5)	67(5.4)	18(3.6)	184(10.5)
Gender						
Male	398(36.7)	1370(45.8) ***	233(40.3)	596(48.1) **	165(32.7)	774(44.1) ***
Female	685(63.3)	1623(54.2)	345(59.7)	643(51.9)	340(67.3)	980(55.9)
Living arrangement						
With children or others	915(84.5)	2203(73.6) ***	491(84.9)	943(76.1) ***	424(84.0)	1260(71.8) ***
Alone	168(15.5)	790(26.4)	87(15.1)	296(23.9)	81(16.0)	494(28.2)
Residence						
Urban	578(53.4)	1239(41.4)***				
Rural	505(46.4)	1754(58.6)				
Health behavior						
Annual Physical Examination						
Yes	532(49.1)	1780(59.5) ***	249(43.1)	695(56.1) ***	283(56.0)	1085(61.9) *
No	551(50.9)	1213(40.5)	329(56.9)	544(43.9)	222(44.0)	669(38.1)
Smoking						
Often	276(25.5)	842(28.1) #	179(31.0)	397(32.0)	97(19.2)	445(25.4) **
Seldom	807(74.5)	2151(71.9)	399(69.0)	842(68.0)	408(80.8)	1309(74.6)
Drinking						
Yes	104(9.6)	442(14.8) ***	59(10.2)	199(16.1) **	45(8.9)	243(13.9) *
No	979(90.4)	2551(85.2)	519(89.8)	1040(83.9)	460(91.9)	1511(86.1)
Physical activity						
Yes	284(26.2)	764(25.5)	206(35.6)	459(37.0)	78(15.4)	305(17.4)
No	799(73.8)	2229(74.5)	372(64.4)	780(63.0)	427(84.6)	1449(82.6)
Health status						
Feeling of lonely						
Often	530(48.9)	1133(37.9) ***	243(42)	425(34.3) **	287(56.8)	708(40.4) ***
Seldom	553(51.1)	1860(62.1)	335(58)	814(65.7)	218(43.2)	1046(59.6)
NCD [b]						
None	429(39.6)	1354(45.2) ***	216(37.4)	532(42.9) **	213(42.2)	822(46.9)
One	338(31.2)	955(31.9)	168(29.1)	383(30.9)	170(33.7)	572(32.6)
≥2	316(29.2)	684(22.9)	194(33.6)	324(26.2)	122(24.2)	360(20.5)
BMI						
Underweight (< 18.5)	303(28.0)	653(21.8) ***	158(27.3)	230(18.6) ***	145(28.7)	423(24.1) #
Normal (18.5-25)	605(55.9)	1931(64.5)	312(54.0)	819(66.1)	293(58.0)	1112(63.4)
Overweight(25-30)	146(13.5)	327(10.9)	86(14.9)	143(11.5)	60(11.9)	184(10.5)
Obesity (> 30)	29(2.7)	82(2.7)	22(3.8)	47(3.8)	7(1.4)	35(2.0)

#p < 0.1, *p < 0.05, **p < 0.01, ***p < 0.001.
[a] Quartile 3 (Q3) is the richest and Quartile 1 (Q1) is the poorest.
[b] NCD: Non-communicable chronic disease.

Table 3 demonstrates logistic regressions analysis of ADL disability among the urban oldest-old in China. The results indicated that BMI was significantly associated with ADL disability. The underweight group had an increased risk of ADL disability; the OR decreased from 1.803 (95%CI:1.417–2.294) in the unadjusted model to 1.400 (95%CI:1.078–1.818) in the final fully adjusted model. Meanwhile, the overweight group also increased the risk of ADL disability; the OR increased from 1.579(95%CI:1.172–2.126) in the unadjusted model to 1.782(95%CI:1.291–2.458) in the final fully adjusted model. In addition, age, living arrangement, annual physical examination, drinking and NCD were important factors associated with ADL disability among the seniors (80+) in the urban areas.

As shown in Table 4, we found no significant differences between BMI and ADL disability among rural oldest old in rural areas whether in unadjusted (model 1) or adjusted (model 2–4). However, age, minority (OR = 0.226, 95%CI 0.134–0.380), living alone (OR = 0.436, 95%CI 0.329–0.578), annual physical examination (OR = 1.405, 95%CI 1.128–1.750), feeling of loneliness (OR = 0.571, 95%CI 0.459–0.712), NCD ≥ 2 (OR = 1.611, 95%CI 1.217–2.132) were associated with disability for rural oldest subgroup.

4. Discussion

The study analyzed the association between disability and BMI

Table 2
Association of ADL disability and BMI among seniors aged 80 and older in China, CLHLS 2014.

Characteristics	Model 1(No covariates) OR(95%)	P	Model2 (Covariates)	P
BMI				
(reference = Normal (18.5-25))				
Underweight (< 18.5)	1.481(1.257–1.745)	0.000	1.206 (1.009,1.441)	0.039
Overweight(25–30)	1.425(1.149–1.768)	0.001	1.593 (1.261,2.013)	0.000
Obesity (> 30)	1.129(0.732–1.741)	0.584	1.105 (0.697,1.752)	0.671
Socio-demographics				
Age (reference = 80–89)				
90–99			2.549 (2.132,3.048)	0.000
100+			4.807 (3.848,6.005)	0.000
Literate (Illiterate)			0.897 (0.741–1.085)	0.262
Single (Couple)			1.231 (1.003–1.510)	0.047
Economical status(reference = Q3)				
Q2			0.863 (0.704–1.058)	0.155
Q1			0.980 (0.731–1.314)	0.893
Minority (Han)			0.377 (0.265–0.535)	0.000
Female (Male)			1.068 (0.875–1.303)	0.520
Living alone (With children or others)			0.511 (0.418–0.625)	0.000
Rural (urban)			0.594(0.507–0.695)	0.000
Health behavior				
Annual Physical Examination (Yes)			1.381 (1.186–1.607)	0.000
Smoking (Often)			0.895 (0.736–1.089)	0.269
Drinking (Yes)			1.438 (1.118–1.850)	0.005
Physical activity (Yes)			1.022 (0.853–1.226)	0.811
Health status				
Feeling of lonely (Often)			0.672 (0.575–0.786)	0.000
NCD (reference = none)				
One			1.210 (1.013–1.446)	0.036
≥2			1.699 (1.402–2.059)	0.000

Table 3
Association of BMI, socio-demographic, health behavior and health status factors with ADL disability among urban seniors aged 80 and older in China, CLHLS 2014 (n = 1817).

Variables	Model 1(No covariates)	Model 2	Model 3	Model 4
BMI (reference = Normal (18.5-25))				
Underweight (< 18.5)	1.803(1.417–2.294) ***	1.436(1.111–1.857) **	1.390(1.074–1.800) *	1.400 (1.078,1.818) *
Overweight(25-30)	1.579(1.172–2.126) **	1.906(1.391–2.612) ***	1.906(1.387–2.618) ***	1.782 (1.291,2.458) ***
Obesity (> 30)	1.229(0.728–2.073)	1.472(0.851–2.545)	1.458(0.838–2.539)	1.340 (0.768,2.338)
Socio-demographics				
Age (reference = 80-89)				
90-99		2.640(2.076–3.357) ***	2.555(2.004–3.257) ***	2.742 (2.140,3.513) ***
100+		4.916(3.536–6.833)***	4.790(3.434–6.681) ***	5.159 (3.669,7.254) ***
Literate (Illiterate)		1.004(0.781–1.290)	0.975(0.755–1.260)	0.955 (0.737,1.238)
Single (Couple)		1.190(0.903–1.567)	1.185(0.898–1.564)	1.151 (0.868,1.526)
Economical status(reference = Q3)				
Q2		0.824(0.638–1.065)	0.797(0.615–1.032) #	0.773 (0.594,1.005) #
Q1		1.068(0.719–1.586)	1.016(0.680k1.518)	0.893 (0.592,1.348)
Minority (Han)		0.609(0.370–1.003)#	0.620(0.375–1.025) #	0.673 (0.405,1.120)
Female (Male)		1.105(0.855–1.428)	1.103(0.832–1.463)	1.071 (0.805,1.426)
Living alone (With children or others)		0.601(0.452–0.797) ***	0.605(0.455–0.805) ***	0.609 (0.456,0.813) **
Health behavior				
Annual Physical Examination (Yes)			1.373(1.110–1.698) **	1.402 (1.131,1.737) **
Smoking (Often)			0.794(0.613–1.029) #	0.835 (0.642,1.086)
Drinking (Yes)			1.698(1.211–2.380) **	1.600 (1.137,2.252) **
Physical activity (Yes)			1.015(0.808–1.274)	1.055 (0.837,1.329)
Health status				
Feeling of lonely (Often)				0.804 (0.640,1.011) #
NCD(reference = none)				
One				1.146 (0.883,1.487)
≥2				1.847 (1.412,2.417) ***
NagelkerkeR^2	0.02	0.141	0.155	0.172

# p < 0.1, *p < 0.05, **p < 0.01, ***p < 0.001.

among Chinese oldest-old. To our knowledge, it is the first study that focuses on rural-urban differences in the association between disability and body mass index among the Chinese oldest-old. The results showed that a significant association between them was observed in urban district, while the relationship was not obvious for rural oldest seniors.

Our findings showed that the prevalence of disability among the oldest-old sample was 26.6%, within 22.4% for rural respondents and 31.8% for urban seniors. The proportion is lower than 31.8% found in Changchun, China (Wang et al., 2017), 33.78% based on the 2011 wave of CLHLS (Yin et al., 2014), and 37.4% in India (Gupta, Mani, Rai, Nongkynrih, & Gupta, 2014). However, it is higher than 20.9% in Japan (Saito, Ueki, Yasuda, Yamazaki, & Yasumura, 2014), and 8.18% based

Table 4
Association of BMI, socio-demographic, health behavior and health status factors with ADL disability among rural seniors aged 80 and older in China, CLHLS 2014 (n = 2259).

Variables	Model 1(No covariates)	Model 2	Model 3	Model 4
BMI (reference = Normal (18.5–25))				
Underweight (< 18.5)	1.301(1.035–1.635) #	1.096(0.859–1.398)	1.073(0.840–1.370)	1.044 (0.815,1.337)
Overweight(25–30)	1.238(0.900–1.702)	1.520(1.082–2.137) #	1.511(1.075,2.126) #	1.378 (0.974,1.949) #
Obesity (> 30)	0.759(0.334–1.726)	0.738(0.312–1.749)	0.717(0.302–1.703)	0.743 (0.310,1.780)
Socio-demographics				
Age (reference = 80–89)				
90–99		2.381(1.843–3.076) ***	2.325(1.797,3.010) ***	2.352 (1.811,3.053) ***
100+		4.285(3.194–5.750) ***	4.327(3.219,5.816) ***	4.417 (3.271,5.966) ***
Literate (Illiterate)		0.830(0.627–1.100)	0.813(0.611–1.081)	0.819 (0.613,1.093)
Single (Couple)		1.353(1.005–1.822) *	1.384(1.027–1.867) *	1.318 (0.975,1.782) #
Economical status(reference = Q3)				
Q2		1.158(0.838–1.601)	1.118(0.807–1.549)	1.037 (0.745,1.445)
Q1		1.426(0.933–2.180)	1.351(0.880–2.075)	1.130 (0.730,1.751)
Minority (Han)		0.249(0.149–0.415) ***	0.229(0.137–0.384) ***	0.226 (0.134,0.380) ***
Female (Male)		1.153(0.892–1.491)	1.091(0.826–1.440)	1.081 (0.817,1.432)
Living alone (With children or others)		0.446(0.337–0.589) ***	0.445(0.336–0.588) ***	0.436 (0.329,0.578) ***
Health behavior				
Annual Physical Examination (Yes)			1.414(1.138–1.756) **	1.405 (1.128,1.750) **
Smoking (Often)			0.980(0.727–1.320)	0.972 (0.719,1.314)
Drinking (Yes)			1.333(0.920–1.931)	1.227 (0.842,1.788)
Physical activity (Yes)			1.018(0.758–1.368)	0.980 (0.727,1.323)
Health status				
Feeling of lonely (Often)				0.571(0.459,0.712) ***
NCD(reference = none)				
One				1.278 (0.998,1.636) #
≥2				1.611 (1.217,2.132) **
NagelkerkeR^2	0.004	0.153	0.161	0182

# p < 0.1, *p < 0.05, **p < 0.01, ***p < 0.001.

on the China health and retirement longitudinal study (CHARLS) (Yang, Hao, Bo, & Sun, 2016).

In the study, the results demonstrated that the association between disability and BMI were different among urban and rural subgroups, which was partly consistent with previous studies (Liu et al., 2018; Yin et al., 2014). The possible explanation is that the access to health care and financial condition in rural areas is not as good as urban areas in China (Zhang et al., 2017). Consequently, urban oldest-old can receive high-quality and timely preventative care and medical services relative to rural counterparts when needed, which is helpful for reducing mortality from obesity-related chronic disease and prolonging life lived with disability, thus strengthening the association between disability and obesity (Koyanagi, Moneta, & Garin, 2015).

For urban oldest-old, both overweight and underweight are indicators of disability, which is partly in agreement with previous studies (Arnold, Newman, Cushman, Ding, & Kritchevsky, 2010). The results of meta-analysis including one Latin American and several developed countries showed that ORs for ADL disability among class II, I obesity and overweight was 1.76,1.16, 1.04, for respectively (Backholer, Wong, Freak-Poli, Walls, & Peeters, 2012). There are two possible explanations for such output. First, overweight is related to high possibility of chronic disease (Yin et al., 2014), poorer mobility (Vincent, Vincent, & Lamb, 2010), low-grade systemic inflammation (Mathieu, Lemieux, & Despres, 2010) and worse joint mechanic (Corbeil, Simoneau, Rancourt, Tremblay, & Teasdale, 2001), which could result in disability. Second, underweight is associated with high risk of falls and fracture (Kim, Kim, Sim, Park, & Choi, 2016), chronic malnutrition (Lahmann, Tannen, & Suhr, 2016), impaired motor function (Honda, Tanabe, Seki, Ogawa, & Suzuki, 2014), thus leading to declining function. The finding suggests that it is significant to monitor the weight for fluctuation of both gain and loss among urban oldest-old in China.

The association between disability and BMI among rural oldest seniors are not supported in our study. Although the health care conditions have been greatly improved recently in most rural areas. Local or village doctors were available (Liu, Zhang, Lu, Kwon, & Quan, 2007), and the coverage of health insurance reached more than 95% as the same as urban areas in 2015 (China MoHRaSSo, 2015). However, as we discussed above, because of the access to health and socio-economical status, many rural older adults are still unable to obtain timely and good medical treatment of obesity-related chronic disease, including renal disease (de Vries, Ruggenenti, & Ruan, 2014), cardiovascular disease and diabetes, which will pose a serious threat to human life (Danaei, Lu, Singh, Carnahan, & Stevens, 2014), weakening the association between disability and obesity to a certain extent (Koyanagi et al., 2015).

Furthermore, the study also shows that age, living arrangement, NCD, and annual physical examination are important influential factors which are related to disability both in urban and rural subgroups. The first three factors are similar with other studies (Chen et al., 2015; Hacihasanoglu, Yildirim, & Karakurt, 2012; Li et al., 2009; Nagarkar & Kashikar, 2017; Su et al., 2016; Wang et al., 2013; Wei & Wu, 2014) worldwide. In addition, our study finds that annual physical examination exerts a statistically negative effect on the possibility of ADL disability. The finding indicates that annual physical examination should be recommended to all of the oldest-old to achieve the healthy aging.

Similarly, ethnicity and feeling of loneliness are important influential factors of disability among rural seniors above 80 years old. Han increased the risk of disability (Li et al., 2009; Luo et al., 2017). Loneliness is also a risk factor of disability which is consistent with the studies in USA (Perissinotto et al., 2012), India (Nagarkar & Kashikar, 2017) and China (Chen et al., 2015; Hsieh, Sung, & Wan, 2010).

Interestingly, drinking is beneficial for the maintenance of ADL among the urban oldest-old. According to the research in Japan, drinkers had significantly higher velocity in maximum walking, stronger grip strength and higher level of competence (Suzuki, Yukawa, & Yoshida, 2000). Furthermore, there is no obvious difference in disability among seniors with different level of alcohol intake (Lang, Guralnik, Wallace, & Melzer, 2007).

The limitations as follows deserve taking into account when interpreting the results. First, some variables including socio-demographic, health behavior and health status were based on self-reported, leading

to the possibility of bias. Second, causal inferences cannot be obtained because of the cross-sectional design. Thus, more longitudinal researches are needed to investigate the possible mechanism between disability and BMI in rural and urban settings. Finally, the missing rate of information on BMI was 14.0% of the participants. It is hard to define whether these data were missing randomly or not. A potential underestimation of the association between disability and BMI may exist due to the exclusion of missing data.

5. Conclusion

The association between BMI and disability differed according to residence among the oldest-old in China. BMI is a significant indicator of disability in Chines adults (80+) in urban district. Both overweight and underweight are red flags of disability among urban oldest seniors. Additionally, age, living arrangement, NCD, and annual physical examination are important determinants for disability both in urban and rural subgroups. According to the findings, proper weight management is important for preventing disability among the oldest-old in urban. Additionally, annual physical examination, prevention and control of chronic diseases should be recommended to all of the oldest-old to achieve the healthy aging.

Conflicts of interest

None

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Authors' contributions

Conceptualization: CQW NC CCZ. **Data curation:** NC XL. **Formal analysis:** NC XL JW. **Funding acquisition:** CQW NC. **Methodology:** NC XL CCZ. **Project administration:** CQW NC. **Software:** NC XL.

Supervision: CQW CCZ JW. **Validation:** CQW CCZ JW. **Writing – original draft:** NC. **Writing – review & editing:** CQW XL.

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