Title page

Interaction of physical activity on the association of obesity-related measures with multi-morbidity among older adults: A population-based cross-sectional study in India

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Background

Considering the demographic shift towards population aging in India, the share of people aged 60 and above is projected to increase from 8.6 percent in 2011 to 20 percent in 2050 (1). India's demographic structure is likely to shift from a young to an aging population beyond the 2030s (2). On the other hand, the prevalence of overweight and obesity among adults worldwide has risen from approximately 27.5% in 1980 to 39% in 2016 (3). Though the prevalence of overweight/obesity is comparatively lower among older adults than the 18-55 age groups, the increasing trend in the prevalence of overweight/obesity over the past four decades is similar among both age groups.

Traditionally the healthcare delivery was built and remained typically centered on the treatment of single diseases. Over the past few decades onsite of the demographic and epidemiologic transition, the growing number of elderly has become a considerable challenge to health care delivery as more than half of the elderly have at least two chronic conditions (4,5). World Health Organization defines multi-morbidity as "the coexistence of two or more chronic conditions in the same individual" (6). Changes in lifestyle and behavioral factors and inactivity and overeating result in impaired body systems functions and culminates in multi-morbidity and increased incidence of NCDs, including cardiovascular diseases, obesity, diabetes, and cancer (7,8).

The negative impacts of overweight/obesity on cardiovascular diseases, diabetes, hypertension, and multi-morbidity are well studied (9,10) and accounted for 4.0 million deaths globally (11). Again, deprivation and health behaviors are significant predictors of multi-morbidity. The public health efforts to modify the social determinants and foster healthy lifestyles can minimize multi-morbidity risk (12). The increased risk of multi-morbidity in young adults and growing numbers of elderly may contribute to the health and social care burden in the coming years (13). Sufficient physical activity across the life course is the key requirement for healthy aging and predictors for reduced mortality (14,15). It is widely recognized that the immune system is influenced by physical activity (16). Unfortunately, increased inactivity across the lifespan due to lifestyle changes and decline in physical activity with ageing might reduce immunity in old ages (8).

Several studies have highlighted the association between physical activity and overweight/obesity among older adults (17–20). Physical inactivity and impaired physical mobility are the primary reasons for overweight/obesity among the elderly due to decreased metabolic rate and body composition changes (21,22). Physical inactivity and poor health behaviors like obesity are major risk factors common to several diseases (23). Regular physical activity is known to improve life quality, prevent various chronic diseases, and reduce premature death risk (24–26). Studies also suggest that better physical activity could be the key to improving outcomes for older adults with multi-morbidity. Physical activity should be promoted as an essential strategy to mitigate the growing burden of multi-morbidity among older adults globally. Fulfilling needs for health care services, physical activity, social protection for the elderly, protecting their rights, and enabling them to contribute to the development process should be priorities in India's coming years.

Furthermore, previous studies revealed that multi-morbidity is associated with socio-demographic characteristics such as age, sex, residence, and economic status. In developed countries, multi-morbidity is more prevalent among lower socioeconomic groups (4,27), while in developing country context, multi-morbidity is more among the wealthier (28,29). Studies show that women and older adults have a higher chance of multi-morbidity than men and younger adults (28,30,31). Like socioeconomic status, there was an assumption that the multi-morbidity burden exists only in developed and industrialized countries. Yadav and Arokiasamy demonstrated the burden of multi-morbidity as a major health concern especially in lower-middle-income countries where the social, behavioural, and lifestyle patterns are altered with rising levels of urbanization and industrialization (32). Evidence shows the urban place of residence is associated with the risk of multi-morbidity (28,33).

No previous study has looked into the interactions between physical activity, obesity measures and associated multi-morbidity among older adults in the Indian context to the best of our knowledge. This novel study using the latest available data may provide new insights on this demanding area and highlight the relative merits of strategies to encourage physical activity among older adults. Thus, the present study explores the associations between obesity measures, physical activity, and multi-morbidity among older Indian adults using large nationally representative data.

Materials and methods

The present study uses data of the Longitudinal Aging Study in India (LASI's) baseline wave (Wave 1) conducted during 2017-18 in India. The survey is a joint undertaking of the Harvard T.H. Chan School of Public Health, the International Institute for Population Sciences (IIPS), and the University of Southern California (USC). The nationally representative longitudinal survey collects vital information on the physical, social, and cognitive well-being of India's older adults which will be followed up for 25 years. The data of over 72,000 individuals aged 45 and above along with their spouses (irrespective of age) is collected across all states and union territories of India. The sample is based on a multistage stratified cluster sample design including three and four distinct stages of rural and urban area selection respectively. The survey provides scientific insights and facilitates a harmonized design which helps in comparing with parallel international studies. Further, the details of sample design, survey instruments, fieldwork, data collection and processing, and response rates are publicly available in the LASI report present on the website Longitudinal Aging Study in India (LASI) (34).

Participants in the study consist of 15,098 male and 16,366 female older adults aged 60 years and above in India. Further, the sample of overweight and high-risk waist circumference and waist-hip ratio may differ from the total sample as some of the older adults did not provide consent for the measurements (34). The survey agencies that conducted the field survey for the data collection have collected prior consent from the respondents. The Indian Council of Medical Research (ICMR) extended the necessary guidelines and ethics approval for undertaking the LASI survey.

Variable description

Outcome description

The outcome variable was coded as binary i.e., multimorbidity (no/yes). Multi-morbidity conditions refer to the presence of two or more chronic diseases which include hypertension, chronic heart diseases, stroke, any chronic lung disease, diabetes, cancer or malignant tumor, any bone/joint disease, neurological/psychiatric disease, or high cholesterol (34). The diseases were self-reported (35) as was assessed through the question "Has any health professional ever diagnosed you with the following chronic conditions or diseases?"

Explanatory variables

The variables controlled for the present study were taken into consideration after an extensive literature review. Overweight/obesity was categorized as no and yes. The respondents having a body mass index of 25 and above were categorized as obese/overweight. High-risk waist circumference was categorized as no and yes (36). Male and female who have waist circumferences of more than 102 cm and 88 cm respectively were considered as having high-risk waist circumference (37). High-risk waist-hip ratio was categorized as no and yes. Male and female who have a waist-hip ratio of more than equal to 0.90 and 0.85 cm respectively were considered as having a high-risk waist-hip ratio (37). Physical activity status was categorized as frequent (every day), rare (more than once a week, once a week, one to three times in a month), and never. The question through which physical activity was assessed was "How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health center or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads"?

Age was categorized as young old (60-69 years), old-old (70-79 years), and oldest-old (80+ years). Education was categorized as no education/primary schooling not completed, primary completed, and secondary completed and higher and above. Marital status was categorized as currently married, widowed, and others (separated/never married/divorced). Working status was categorized as working, retired, and not working. Tobacco and alcohol consumption was coded as no and yes.

The monthly per capita expenditure (MPCE) quintile was measured using household consumption data. Sets of 11 and 29 questions on the expenditures on food and non-food items, respectively, were used to canvas the sample households. Food expenditure was collected based on a reference period of seven days, and non-food expenditure was collected based on reference periods of 30 days and 365 days. Food and non-food expenditures have been standardized to the 30-day reference period (34). The monthly per capita consumption expenditure (MPCE) is computed and used as the summary measure of consumption. The variable was then divided into five quintiles i.e., from poorest to richest. Religion was categorized as Hindu, Muslim, Christian, and Others. Caste was categorized as Scheduled Tribe, Scheduled Caste, Other Backward Class, and others. The Scheduled Caste include "untouchables"; a group of population that is socially segregated and financially/economically by their low status as per Hindu caste hierarchy. The Scheduled Castes (SCs) and Scheduled Tribes (STs) are among the most disadvantaged socio-economic groups in India. The OBC is the group of people who were identified as "educationally,

economically and socially backward". The OBC's are considered low in the traditional caste hierarchy but are not considered untouchables. The "other" caste category is identified as having higher social status. Place of residence was categorized as rural and urban. The region was categorized as North, Central, East, Northeast, West, and South.

Statistical analysis

Descriptive statistics along with bivariate analysis were presented in the present paper. Chi-square test was used to compare the intergroup differences and to report the significance level (38,39). Additionally, binary logistic regression analysis (40) was used to establish the association between outcome variable (multimorbidity) and other explanatory variables.

The binary logistic regression model is usually put into a more compact form as follows:

$$\text{Logit}\,[\text{P}(\text{Y}=1)] = \beta_0 + \beta * X + \epsilon$$

The parameter β_0 estimates the log odds of the multimorbidity for the reference group, while β estimates the maximum likelihood, the differential log odds of the multimorbidity associated with a set of predictors X, as compared to the reference group and ϵ represents the residual in the model.

The multivariate analysis had four models to explain the adjusted estimates. Model-1 provides the adjusted estimates for the control variables. Model-2, model-3, and model-4 provide the interaction effects (41,42) for obesity indicator and physical activity status with multimorbidity among older adults. An "interaction variable" is a variable constructed from an original set of variables to try to represent either all of the interaction present or some part of it. In exploratory statistical analyses, it is common to use products of original variables as the basis of testing whether the interaction is present with the possibility of substituting other more realistic interaction variables at a later stage. When there are more than two explanatory variables, several interaction variables are constructed, with pairwise products representing pairwise-interactions and higher-order products representing higher-order interactions (41–44).

Thus, for a response *Y* and two variables x_1 and x_2 an *additive* model would be:

$$\text{Y} = \alpha + \beta_1\, \text{x}_1 + \beta_2\, \text{x}_2 + \varepsilon_0$$

In contrast to this,

$$\text{Y} = \alpha + \beta_1\, \text{x}_1 + \beta_2\, \text{x}_2 + (\beta_3\, \text{x}_\text{s} * \text{x}_\text{a})\, \varepsilon_0$$

Where, Y is the dependent variable (multimorbidity) and α is intercept, x_1 is individual-level independent variable, x_2 is individual level independent variable, x_a is obesity indicators, x_s is physical activity, ($\beta_3 x_s * x_a$) is the interaction of obesity indicators and psychical activity and ε_0 is error. Often, models are presented without the interaction term d ($x_1 * x_2$), but this confounds the main effect and interaction effect (i.e., without specifying the interaction term, it is possible that any main effect found is actually due to interaction) (45).

Patient and Public Involvement

No patient involved

Results

Table 1 represents the socio-demographic and economic profile of older adults in the LASI cohort. The table reveals that about one-fifth of the older adults were overweight/obese. Nearly, one-fourth of the older adults had high-risk waist circumference while about 8 in 10 older adults had a high risk waist-hip ratio. Around 69% of the older adults never did physical activity while only 18% of the older adults did frequent physical activities. Around 62% of the older adults were currently married and 36% of older adults were widowed. Among the category of working status, about 43% of the older adults were retired while around 31% of the older adults were presently working. The older adults who consumed tobacco and alcohol were around 40% and 14% respectively.

Table 2 shows the percentage of older adults suffering from multi-morbidity in the LASI cohort. It was found that nearly 43% of the older adults who were overweight/obese had multi-morbidity. About 42% and 26% of the older adults who had high-risk waist circumference and high-risk waist-hip ratio respectively were suffering from multi-morbidity. About 27% of the older adults who never did physical activities had multi-morbidity. The status of multi-morbidity among the older adults showed an increasing trend with rising educational status. About 26% of the older adults who were widowed were suffering from multi-morbidity. The share of older adults suffering from multi-morbidity was directly proportional to the MPCE quintile. Among the religious groups, the share of older adults suffering from multi-morbidity was highest and lowest among the Christians (31%) and Hindu (23%) respectively. Older adults from Scheduled Tribe (11.1%) suffered from the lowest share of multimorbidity among all the caste groups. Among the regions of India, south India (32%) recorded the highest share of older adults suffering from multi-morbidity while

central India (14%) recorded the lowest share. Overall about 24% of older adults in the LASI cohort suffered from multi-morbidity.

Table 3 gives a representation of the logistic regression of the older adults who were suffering from multi-morbidity. It was found that the older adults who were overweight/obese were 61% significantly more likely to have multi-morbidity in comparison to those who were not overweight/obese [AOR: 1.61, CI: 1.48-1.74]. The older adults with high-risk waist circumference and high-risk waist-hip ratio were 66% [AOR: 1.66, CI: 1.52-1.80] and 45% [AOR: 1.45, CI: 1.33-1.59] significantly more likely to suffer from multi-morbidity respectively in reference to those who do not have high-risk waist circumference and high-risk waist-hip ratio respectively. The odds of multi-morbidity were significantly higher among the older adults who were physically inactive in reference to the older adults who were physically active [AOR: 1.33, CI: 1.21-1.46]. The likelihood of multi-morbidity among females was significantly low in comparison to males [AOR: 0.86, CI: 0.79-0.94]. The odds of multi-morbidity were significantly higher among the older adults who were not working in reference to the older adults who were currently working [AOR: 1.77, CI: 1.6-1.96].

Surprisingly, the odds of multi-morbidity were 98% significantly more likely among the older adults who were from the richest MPCE quintile in reference to the older adults who belonged to the poorest MPCE quintile [AOR: 1.98, CI: 1.79-2.19]. The older adults who were from the Scheduled Tribes category were 33% significantly less likely to suffer from multi-morbidity in comparison to older adults who were from the Scheduled Caste category [AOR: 0.67, CI: 0.59-0.77]. The older adults residing in urban areas were 43% significantly more likely to suffer from multi-morbidity in reference to the older adults residing in the rural areas [AOR: 1.43, CI: 1.34-1.53]. The odds of multi-morbidity were significantly higher among the older adults of the southern region as compared to the older adults of the northern region [AOR: 1.88, CI: 1.71-2.07]. The older adults who were obese and were physically inactive were 21% significantly more likely to suffer from multi-morbidity in reference to the older adults who were obese and were physically active [AOR: 1.21, CI: 1.04-1.4]. The older adults with high-risk waist circumference and physically inactive status had a 30% significantly higher likelihood to suffer from multimorbidity in comparison to older adults with high-risk waist circumference and physically active status [AOR: 1.30, CI: 1.11-1.53]. The older adults with a high-risk waist-hip ratio and physically inactive status had a 32% significantly higher likelihood to suffer from multimorbidity in comparison to older adults with a high-risk waist-hip ratio and physically active status [AOR: 1.32, CI: 1.20-1.46].

Discussion

Based on a large nationally representative sample of older Indian adults aged 60 and above, the present study has shown the associations between several anthropometric measures and multi-morbidity in later years of life. It also examined the interactive effect of physical activity in those associations. The results were statistically significant even after adjusting for a wide range of variables in the study. The higher prevalence of multimorbidity among older men than women was contrary to earlier studies that found a female disadvantage in the co-occurrence of multiple diseases (46,47). This differential can be explained by the survival bias that suggests that women who survive may have a better health condition than men who have a shorter life expectancy (48).

In concordance with a growing body of research that is based on several cross-sectional as well as longitudinal datasets, in the present study, lack of physical activity was associated with a higher likelihood of multimorbidity (49–51). There is also a likely reverse causal pathway by which chronic conditions contribute to physical inactivity increasing the risk of sedentary lifestyles, which in turn could increase the risk of additional chronic conditions such as cholesterol and diabetes, producing a vicious cycle between multimorbidity and physical inactivity. On the other hand, results of the study on other unhealthy lifestyle factors such as smoking and alcohol consumption showing no association with multimorbidity are at variance with multiple studies that found smoking habit and drinking as risk factors of the simultaneous presence of two-plus chronic conditions (52–54). The finding, however, concurs with a recent study that found an association of smoking and alcohol drinking only in combination with other lifestyle factors (55).

Of the risk factors examined, obesity/overweight, high-risk waist circumference, and high-risk waist-hip ratio were also associated with multimorbidity. Consistent with past studies, multimorbidity was reported more often by older adults whose obesity-related anthropometric measures were found to be at risk (56–58). Further, waist-hip ratio and waist circumference are shown to be more sensitive among several anthropometric indices of obesity while screening for multimorbidity (59–61). The present study in line with earlier studies found a positive association between both measures and multimorbidity (37). Thus, results confirm the association of obesity-related anthropometric measures with multi-morbidity that has been repeatedly shown in past studies (49,62,63).

Besides, studies have revealed the independent associations of obesity and other related high-risk body measures with physical inactivity (64–67). The other way around, although we adjusted for many of the socio-demographic and lifestyle variables to minimize reverse causality, it is possible to construct a reverse relationship of multimorbidity being the cause of overweight/obesity. Hence, future prospective longitudinal studies are required to identify the causality. Further, results of the statistical tests on interactions of obesity-related measures with physical activity in our study show that multimorbidity was more prevalent among older adults who were obese/ overweight or at risk of waist-hip ratio and waist circumference with non-performance of any physical activity. The findings of the current analysis that apply to an older population of a developing country highlight the urgent need for further investigation of the effectiveness of physical activity in the management of chronic diseases in low and middle-income countries.

Further, the association between multimorbidity and age is well documented in the literature. Consistently, the current analysis shows that a higher age group is a risk factor of multimorbidity and supports the notion that the additional life years may constitute an increased chance of acquiring other chronic conditions (23,46). With respect to socioeconomic patterning of multimorbidity, there are inconsistencies in developing countries regarding whether it is concomitant to the wealthy with a lesser impact on the poor or present among the population across all the socioeconomic spectrum (30,68–70). However, the present study found that multimorbidity tends to be higher among individuals with higher levels of education, belonging to households with higher wealth quintiles and non-SC/STs. The finding is consistent with past studies that have shown statistically significant positive associations between socioeconomic variables such as education, household wealth, and higher social groups and the prevalence of multimorbidity (71).

Strengths of the present study include the large nationally representative sample of the older population and objective obesity-related measures. There were some limitations also. Firstly, the cross-sectional design of the study makes it impossible to establish the observed directions of the relationships. Another limitation of the study is that it uses a relatively simple definition of counting diseases for measuring multi-morbidity compared with past studies (72–74). Similarly, lifestyle factors were self-reported in the survey data and thus susceptible to measurement error. Also, the overweight and obese are not split as separate categories due to relatively small sample size in the latter category and as also found in some other studies (75). Finally, as a limitation for physical activity, the descriptors to assess

activity in the present study do not include many female biased categories such as various aspects of housework and the data for females may over-estimate the never or rare category in the current analyses.

Conclusion

The high prevalence of multimorbidity implies the need for a holistic approach beyond the management of individual diseases. Given that multimorbidity results in substantial life years lost, for increased quality life years in the older ages, it is necessary to understand how to manage co-occurring morbidities simultaneously. While developing health strategies for older adults, physical activity needs to be recognized as a way of minimizing co-morbidities. Further, the study highlights the importance of using multiple obesity-related measures to predict chronic conditions in the older population.

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Table-1 Socio-demographic and economic profile of older adults in LASI cohort, India

Background characteristics	Sample	%
Obese/overweight[a]		
No	21833	77.8
Yes	6217	22.2
High-risk waist circumference[a]		
No	21399	76.3
Yes	6651	23.7
High-risk waist-hip ratio[a]		
No	6434	23.0
Yes	21593	77.0
Physical activity status		
Frequent	5651	18.0
Rare	4023	12.8
Never	21790	69.3
Age (in years)		
Young-old	18410	58.5
Old-old	9501	30.2
Oldest-old	3553	11.3
Sex		
Male	14931	47.5
Female	16533	52.6
Education		
No education/primary not completed	21380	68.0
Primary completed	3520	11.2
Secondary completed	4371	13.9
Higher and above	2191	7.0
Marital status		
Currently married	19391	61.6
Widowed	11389	36.2
Others	684	2.2
Working status		
Working	9680	30.8
Retired	13470	42.8
Not working	8314	26.4
Tobacco consumption		
No	18964	60.3
Yes	12500	39.7
Alcohol consumption		
No	26924	85.6
Yes	4540	14.4
MPCE quintile		
Poorest	6829	21.7
Poorer	6831	21.7
Middle	6590	21.0
Richer	6038	19.2
Richest	5175	16.5
Religion		
Hindu	25871	82.2
Muslim	3548	11.3

	Christian	900	2.9
	Others	1145	3.6
Caste			
	Scheduled Caste	5949	18.9
	Scheduled Tribe	2556	8.1
	Other Backward Class	14231	45.2
	Others	8729	27.7
Place of residence			
	Rural	22196	70.6
	Urban	9268	29.5
Region			
	North	3960	12.6
	Central	6593	21.0
	East	7439	23.6
	Northeast	935	3.0
	West	5401	17.2
	South	7136	22.7
Total		31,464	100.0

[a] The sample may differ as all older adults did not gave consent for the measurements.

Table-2 Percentage of older adults suffering from multi-morbidity in LASI cohort, India

Background characteristics	%	p-value
Obese/overweight		0.001
No	18.4	
Yes	42.6	
High-risk waist circumference		0.001
No	18.1	
Yes	42.1	
High-risk waist-hip ratio		0.001
No	16.2	
Yes	26.0	
Physical activity status		0.001
Frequent	17.0	
Rare	15.8	
Never	27.2	
Age (in years)		0.001
Young-old	22.8	
Old-old	25.8	
Oldest-old	24.5	
Sex		0.001
Male	22.2	
Female	25.4	
Education		0.001
No education/primary not completed	19.7	
Primary completed	30.1	
Secondary completed	33.6	
Higher and above	35.2	
Marital status		0.044
Currently married	23.1	
Widowed	25.6	
Others	18.9	
Working status		0.001
Working	13.6	
Retired	26.9	
Not working	30.9	
Tobacco consumption		0.001
No	26.7	
Yes	19.6	
Alcohol consumption		0.001
No	24.6	
Yes	19.8	
MPCE quintile		0.001
Poorest	16.6	
Poorer	20.2	
Middle	22.2	
Richer	27.9	
Richest	35.9	
Religion		0.001
Hindu	23.2	
Muslim	26.0	

	Christian	31.2	
	Others	27.6	
Caste			0.001
	Scheduled Caste	19.5	
	Scheduled Tribe	11.1	
	Other Backward Class	24.9	
	Others	29.0	
Place of residence			0.001
	Rural	19.1	
	Urban	35.4	
Region			0.001
	North	24.4	
	Central	13.5	
	East	22.9	
	Northeast	16.0	
	West	27.7	
	South	32.4	
Total		24.0	

p-value based on chi-square test.

Table-3 Logistic regression estimates for multimorbidity among older adults in LASI cohort, India

Background characteristics	Model-1	Model-2	Model-3	Model-4
	AOR 95% CI	AOR 95% CI	AOR 95% CI	AOR 95% CI
Obese/overweight				
No	Ref.		Ref.	Ref.
Yes	1.61*(1.48,1.74)		1.61*(1.48,1.74)	1.60*(1.48,1.74)
High-risk waist circumference				
No	Ref.	Ref.		Ref.
Yes	1.66*(1.52,1.8)	1.66*(1.52,1.81)		1.66*(1.52,1.81)
High-risk waist-Hip ratio				
No	Ref.	Ref.	Ref.	
Yes	1.45*(1.33,1.59)	1.45*(1.33,1.59)	1.45*(1.33,1.59)	
Physical activity status				
Frequent	Ref.			
Rare	1.03(0.91,1.16)			
Never	1.33*(1.21,1.46)			
Age (in years)				
Young-old	Ref.	Ref.	Ref.	Ref.
Old-old	1.26*(1.17,1.34)	1.25*(1.17,1.34)	1.26*(1.17,1.34)	1.26*(1.17,1.34)
Oldest-old	1.10(0.99,1.22)	1.09(0.98,1.22)	1.10(0.98,1.22)	1.10(0.99,1.22)
Sex				
Male	Ref.	Ref.	Ref.	Ref.
Female	0.86*(0.79,0.94)	0.86*(0.79,0.94)	0.86*(0.79,0.94)	0.86*(0.79,0.94)
Education				
No education/primary not completed	Ref.	Ref.	Ref.	Ref.
Primary completed	1.27*(1.16,1.4)	1.27*(1.16,1.4)	1.28*(1.16,1.4)	1.28*(1.16,1.4)
Secondary completed	1.29*(1.18,1.41)	1.29*(1.18,1.41)	1.29*(1.18,1.41)	1.29*(1.18,1.41)
Higher and above	1.24*(1.1,1.39)	1.24*(1.1,1.39)	1.24*(1.1,1.39)	1.24*(1.1,1.39)
Marital status				
Currently married	Ref.	Ref.	Ref.	Ref.
Widowed	0.97(0.9,1.04)	0.97(0.9,1.04)	0.97(0.9,1.04)	0.97(0.9,1.04)
Others	0.81*(0.67,0.99)	0.81*(0.67,0.99)	0.81*(0.67,0.99)	0.81*(0.67,0.99)

Working status					
	Working	Ref.	Ref.	Ref.	Ref.
	Retired	1.79*(1.64,1.94)	1.78*(1.64,1.94)	1.78*(1.64,1.94)	1.79*(1.64,1.94)
	Not working	1.77*(1.6,1.96)	1.76*(1.59,1.95)	1.77*(1.6,1.96)	1.77*(1.6,1.96)
Tobacco consumption					
	No	Ref.	Ref.	Ref.	Ref.
	Yes	1.01(0.94,1.09)	1.01(0.94,1.09)	1.01(0.94,1.09)	1.01(0.94,1.09)
Alcohol consumption					
	No	Ref.	Ref.	Ref.	Ref.
	Yes	1.04(0.95,1.14)	1.04(0.95,1.14)	1.04(0.95,1.14)	1.04(0.95,1.14)
MPCE quintile					
	Poorest	Ref.	Ref.	Ref.	Ref.
	Poorer	1.23*(1.11,1.36)	1.23*(1.11,1.36)	1.23*(1.11,1.36)	1.23*(1.11,1.36)
	Middle	1.39*(1.26,1.53)	1.39*(1.26,1.53)	1.39*(1.26,1.53)	1.39*(1.26,1.53)
	Richer	1.60*(1.45,1.77)	1.60*(1.45,1.77)	1.60*(1.45,1.77)	1.60*(1.45,1.77)
	Richest	1.98*(1.79,2.19)	1.98*(1.79,2.19)	1.98*(1.79,2.19)	1.98*(1.79,2.19)
Religion					
	Hindu	Ref.	Ref.	Ref.	Ref.
	Muslim	1.32*(1.21,1.45)	1.32*(1.21,1.45)	1.33*(1.21,1.45)	1.32*(1.21,1.45)
	Christian	1.20*(1.06,1.36)	1.20*(1.06,1.36)	1.20*(1.06,1.36)	1.20*(1.06,1.36)
	Others	1.12(0.97,1.29)	1.12(0.98,1.29)	1.12(0.97,1.29)	1.12(0.97,1.29)
Caste					
	Scheduled Caste	Ref.	Ref.	Ref.	Ref.
	Scheduled Tribe	0.67*(0.59,0.77)	0.67*(0.59,0.77)	0.67*(0.59,0.77)	0.67*(0.59,0.77)
	Other Backward Class	1.02(0.93,1.12)	1.02(0.93,1.12)	1.02(0.93,1.12)	1.02(0.93,1.12)
	Others	1.10*(1.00,1.22)	1.10*(1.00,1.22)	1.10*(1.00,1.22)	1.10*(1.00,1.22)
Place of residence					
	Rural	Ref.	Ref.	Ref.	Ref.
	Urban	1.43*(1.34,1.53)	1.43*(1.34,1.53)	1.43*(1.34,1.53)	1.43*(1.34,1.53)
Region					
	North	Ref.	Ref.	Ref.	Ref.
	Central	0.71*(0.63,0.8)	0.71*(0.63,0.8)	0.71*(0.63,0.8)	0.71*(0.63,0.8)

East	1.21*(1.09,1.33)	1.2*(1.09,1.33)	1.21*(1.09,1.33)	1.21*(1.09,1.34)
Northeast	0.72*(0.63,0.83)	0.72*(0.63,0.83)	0.72*(0.63,0.83)	0.72*(0.63,0.83)
West	1.42*(1.28,1.58)	1.42*(1.28,1.58)	1.42*(1.28,1.58)	1.42*(1.28,1.58)
South	1.88*(1.71,2.07)	1.88*(1.71,2.07)	1.88*(1.71,2.07)	1.88*(1.71,2.07)
Obese/overweight # Physical activity status				
Yes # frequent		Ref.		
No # frequent		0.55*(0.46,0.66)		
No # rare		0.59*(0.49,0.7)		
No # never		0.77*(0.66,0.9)		
Yes # rare		0.97(0.79,1.2)		
Yes # never		1.21*(1.04,1.4)		
High-risk waist circumference #Physical activity status				
Yes # frequent			Ref.	
No # frequent			0.59*(0.49,0.71)	
No # rare			0.59*(0.49,0.72)	
No # never			0.80*(0.68,0.94)	
Yes # rare			1.10(0.88,1.38)	
Yes # never			1.30*(1.11,1.53)	
High-risk waist-hip ratio # Physical activity status				
Yes # frequent				Ref.
No # frequent				0.68*(0.54,0.84)
No # rare				0.61*(0.47,0.79)
No # never				0.94(0.82,1.07)
Yes # rare				1.06(0.93,1.20)
Yes # never				1.32*(1.20,1.46)

Ref: Reference; #: Interaction; *if p<0.05; AOR: Adjusted Odds Ratio; CI: Confidence interval