Prevalence of Smartphone Addiction and its Relationship with Obesity among Young Adults: A Cross-sectional Study from Delhi, India

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Abstract

Smartphone addiction (SA) has emerged as an important health concern worldwide. Recent studies have recognized SA as one of the factors that promote sedentarism and can contribute to obesity. However, the relationship between SA and obesity among Indian young adults remains understudied. The present study aims to estimate the prevalence of SA and explore its association with general and central obesity among young adults in Delhi, India. This cross-sectional study was conducted among 246 young adults (aged 18–30 years) of either sex (60.16% females) from Delhi. Screening for SA was done using the Smartphone Addiction Scale–Short Version. Somatometric measurements (height, weight, waist circumference, and hip circumference) were taken to determine general and central obesity. SA was prevalent among 25.2% of the participants. The prevalence of SA was higher among males and undergraduate students than among females and postgraduate/MPhil/PhD students, respectively. Further, SA was not associated with any of the obesity variables. Interestingly, smartphone addicts were found to have a 2.5-fold increased risk of being underweight. Though SA was not associated with obesity, it was found to be associated with being underweight, indicating a relationship between smartphone use and nutritional status among young adults.

Keywords: Body mass index, central obesity, obesity, smartphone addiction, undernutrition

Introduction

Smartphones, with their touch-screen interface and a multitude of apps, have become an essential part of modern life.[1,2] They blend the functionality of traditional phones and computers into a compact device.[1,2] While smartphones offer convenience, studies have revealed a concerning trend where people are devoting increasingly more time to their smartphone usage.[1,2] Various terminologies are used to describe increased smartphone usage, including smartphone addiction (SA), problematic mobile phone use, mobile phone dependency, and compulsive mobile phone use.[2] In recent times, the term SA has become more commonly used.[2]

Although smartphone users of all age groups can be at risk of addiction, studies have reported that adolescents and young adults may be at particular risk.[3,4] Globally, the prevalence of SA among children, adolescents, and young adults ranges from 10% to 67%.[3,4] In India, the prevalence of SA among adolescents and young adults ranges from 24.6% to 44%.[5-8]

Prolonged usage of smartphones or SA has been associated with several health implications, including increased risk of musculoskeletal discomfort, depression, anxiety, poor sleep quality, exhaustion, and obesity or overweight.[3,9-11] Of these health implications, this study focuses on the relationship between SA and obesity.

Obesity is an important public health issue affecting a wide spectrum of people worldwide.[12,13] As per the National Family Health Survey-5 (NFHS-5), the prevalence of obesity in India was 24% among females and 22.9% among males during 2019–2021.[14] Other studies have reported an even higher prevalence of overweight/obesity in India (up to 40.3%).[15,16]

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Obesity among young adults is of particular concern, as obesity at a young age has been found to be associated with an increased risk of adverse health conditions, early morbidity, and mortality.[12,17]

Imbalances in energy (carbohydrate and fat) intake and expenditure, coupled with a sedentary lifestyle and a lack of physical exercise, are among the primary risk factors for overweight/obesity.[12,13] Recent studies have recognized SA as an important factor behind increased sedentary behavior and maladaptive eating behaviors among youth and may, in turn, be associated with the risk of overweight/obesity.[18-21] However, there is a paucity of studies exploring the relationship between SA and obesity in the Indian context.

Further, most of these studies are from the pre-coronavirus disease (COVID)-19 period; however, screen time, as well as the prevalence of SA, have been reported to have increased since the COVID-19 pandemic.[22] Given that India has a large number of smartphone users, a thorough investigation into how SA is affecting public health warrants urgent research. Accordingly, the present study aims to estimate the prevalence of SA and explore its association with general and central obesity among young adults in Delhi, India.

Material and Methods

Study design and participants

The present cross-sectional study was conducted among 246 young adults (age group: 18–30 years; mean age: 21.79 ± 2.66 years) of either sex (60.16% females) residing in Delhi, India. The participants were recruited from colleges and departments of the University of Delhi, Delhi, using the convenience sampling method. All the recruited participants were apparently healthy (no self-reported physical or mental illness). Individuals suffering from chronic illnesses (CVDs, cancers, etc.), those on long-term medication, and pregnant and lactating mothers were excluded.

The study was approved by the Departmental Ethics Committee, Department of Anthropology, University of Delhi (Ref No: Anth/2022-23/526 and Ref No: Anth/2022-23/532). Informed written consent, typed in English, was obtained from each individual prior to recruitment.

Sample size calculation

Since the reported prevalence of obesity among young adults was lower than that of SA in Delhi,[5,23] the prevalence of obesity was used to calculate the sample size. To calculate the sample size, the following formula was used: $n = \frac{z^2 \hat{p}(1-\hat{p})}{\varepsilon^2}$; where n is the required sample size for adequate power (>80%), 95% confidence level, and 5% error margin; z = 1.96 (for 95% confidence level), $\hat{p}$ is the expected prevalence of general obesity, which was taken to be 12.12% (as reported by Aggarwal *et al*.),[23] and ε is the margin of error, which was taken as 0.05. The calculated sample size was 164. With an additional 50% margin, a total of 246 individuals were recruited.

Data collection

Sociodemographic variables: Data on sociodemographic variables like name, age, sex, education, religion, and social category were collected using pretested and modified interview schedules.

Smartphone addiction: The Smartphone Addiction Scale–Short Version (SAS-SV) was used for SA screening.[24] SAS-SV is a 10-item and 60-point widely used and validated questionnaire for determining the level of SA.[24] The questionnaire has 10 items that describe daily-life disruption, pleasant anticipation, withdrawal, cyberspace-oriented relationship, overuse, and tolerance. Participants rate each item on a 6-point scale ranging from 1 (strongly disagree) to 6 (strongly agree). Depending on responses, an individual can get a minimum of 10 and a maximum of 60 scores. SA has been defined as a score greater than 31 among males and 33 among females.[24]

Somatometric measurements: Height, weight, waist circumference (WC), and hip circumference (HC) were measured following standard protocol. Body mass index (BMI) was computed by dividing body weight in kilograms by height in meter square (kg/m^2). Normal weight was defined as BMI = 18.0–22.9 kg/m^2; overweight as BMI ≥23.0 kg/m^2 but <25.0 kg/m^2, obesity as BMI ≥25.0 kg/m^2, and underweight as BMI <18.0 kg/m^2.[25] High WC was defined as WC ≥90 cm for men and ≥80 cm for women.[25] Waist-hip ratio (WHR) was calculated by dividing WC (in cm) by HC (in cm). High WHR was defined as WHR ≥0.90 for men and ≥0.80 for women.[25]

Statistical analyses

Statistical Package for Social Sciences (SPSS) version 22 was used for the statistical analysis of the data. The prevalence was expressed as number with a percentage. The Chi-square test was used to ascertain differences between categorical variables. Pearson correlation analysis was used to measure the degree of correlation between SA and studied obesity parameters. Linear and logistic regression analyses were performed to understand the association between SA and the studied obesity parameters. Logistic regression models were adjusted for sex, education, religion, and social category. Statistical significance was defined as a *P*-value ≤0.05.

Result

Prevalence of SA in the overall sample and sociodemographic subgroup

Among the participants, 25.2% (n = 62) were found to be smartphone addicts [Table 1]. The prevalence of SA was found to be significantly higher among males (33%) than among females (20.1%) (*P* value = 0.023*), and among undergraduate students (32.3%) than among postgraduate (19.5%) and MPhil/PhD students (15.2%) (*P*-value = 0.04*). However, no significant difference in the prevalence of SA was observed with respect to religion and social category [Table 1].

Relationship between SA and obesity parameters

The prevalence of general and central obesity was not found to be significantly different among the participants with and without SA [Table 2]. Nevertheless, while the proportion of individuals with a normal BMI was higher in the nonaddict category, underweight individuals were relatively higher in the smartphone addict category [Table 2]. However, this trend did not reach the level of statistical significance.

Correlation and regression analyses were performed to understand the relationship between SA and obesity parameters. Pearson correlation and linear regression analyses did not reveal any significant relationship between SA and general and central obesity parameters [Supplementary Table 1]. Again, in adjusted odds ratio analysis, SA was not found to be a risk factor for general or central obesity [Figure 1]. However, smartphone addicts were found to be at a 2.5-fold significantly increased risk of being underweight than non-addicts [Figure 1].

Discussion

The present study aimed to estimate the prevalence of SA and its association with general and central obesity among young adults in Delhi. In the present study, SA was prevalent among 25.2% of the participants. This prevalence rate is comparable to the SA prevalence reported in other studies from India and other countries.[8,26-28] For instance, the prevalence of SA was found to be 24.65% among medical students in central India,[8] 27.6% among the general population of Tamil Nadu,[26] 29.8% among medical students in China,[27] and 27.2% among university students in Saudi Arabia.[28] However, higher prevalence has also been reported[6,29]; for instance, 36.8% among medical university students from

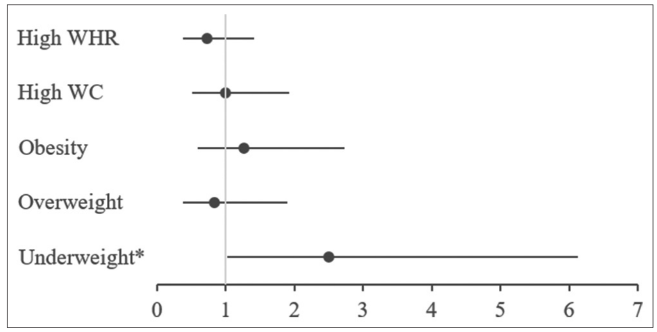

Figure 1: Odds ratio indicating the risk for general and central obesity with SA as a risk factor; WC = waist circumference; WHR = waist-hip ratio; *significant at *P* value <0.05

Table 1: Prevalence of SA in the overall sample and sociodemographic subgroup

Sociodemographic variables	Status	Not addicted *n* (%)	Addicted *n* (%)	*P*
Total participants		184 (74.8)	62 (25.2)	-
Sex	Male	65 (67)	32 (33)	0.023*
	Female	119 (79.9)	30 (20.1)	
Religion	Majority (Hindu)	160 (75.8)	51 (24.2)	0.261
	Minority	22 (66.7)	11 (33.3)	
Social category	UR	88 (78.6)	24 (21.4)	0.187
	OBC	51 (77.3)	15 (22.7)	
	SC	13 (72.2)	5 (27.8)	
	ST	8 (53.3)	7 (46.7)	
Education	Undergraduate	86 (67.7)	41 (32.3)	0.040*
	Postgraduate	66 (80.5)	16 (19.5)	
	MPhil/PhD	28 (84.8)	5 (15.2)	

*Significant at *P*<0.05; *n*=count; %=row-wise percentage; UR=unreserved; OBC=other backward classes; SC=scheduled castes; ST=scheduled tribes; Minority=Christianity, Sikhism, Jainism, Buddhism

Table 2: Distribution of obesity variables with respect to SA status

Obesity parameters	Status	Not addicted *n* (%)	Addicted *n* (%)	*P*
BMI	Normal	75 (41.9)	21 (33.9)	0.179
	Underweight	17 (9.5)	12 (19.4)	
	Overweight	45 (25.1)	13 (21.0)	
	Obesity	42 (23.5)	16 (25.8)	
WC	Normal	129 (71.3)	45 (72.6)	0.844
	High	52 (28.7)	17 (27.4)	
WHR	Normal	98 (54.1)	42 (67.7)	0.061
	High	83 (45.9)	20 (32.3)	

n=count; % = column-wise percentage; BMI=body mass index; WC=waist circumference; WHR=waist-hip ratio

South India,[6] and 45.1% among undergraduate students from Maharashtra.[29]

Regarding SA prevalence in sociodemographic subgroups, males were found to be relatively more addicted to smartphones than females in the present study. This finding is in concordance with some of the previous studies.[5,30] One of the possible reasons behind this observation could be that males are more likely to engage in online gaming.[31] However, other studies have reported no gender differences in SA prevalence, while others have found SA to be more prevalent among females.[4,32] Furthermore, in the present study, SA was found to be more prevalent among undergraduate students than among postgraduate and MPhil/PhD students. Some of the possible reasons behind this observation could be younger age, and less academic load and among undergraduate students than among postgraduate and MPhil/PhD students.[2,33]

An important point worth highlighting is that the studies that were conducted during the COVID-19 pandemic lockdown periods have reported a much higher prevalence of SA (ranging from 27% to 84%)[34] than those studies before the pandemic period,[26-28] as well as the present study (conducted after the lockdown was lifted). The lower prevalence of SA in the present study can be extrapolated to suggest that the effect of the COVID-19 pandemic on screen time and SA may be rather provisional. The prevalence of SA may have decreased after the COVID-19 lockdown period due to the resumption of normalcy. Further research is needed to examine this proposition.

In terms of the relationship between SA and obesity, this study did not find any significant association between SA and general and central obesity. Some of the previous studies have reported similar findings[35,36]; however, contradictory findings have also been reported where SA has been found to be a risk factor for obesity.[11,18] One of the possible reasons behind the lack of association between SA and obesity parameters in the present study could be that the study sample primarily consists of young college students. The participants of the present study are college-going students and are likely to have a physically active lifestyle, despite SA. Further, it is worth noting that smartphone use among youth has been linked to body image distortion and the adoption of weight loss behaviors.[37] This connection may also be intertwined with the emergence of gym and yoga cultures among urban young adults.[38,39] These lifestyle factors are likely to modulate the relationship between smartphone use and obesity. Since lifestyle is greatly affected by age, the relationship between SA and obesity parameters may vary in different age groups.

Interestingly, in the present study, those participants who were addicted to smartphones were at a 2.5-fold higher risk of being underweight than those who were not. This observation reinforces the proposition that SA is likely to affect the nutritional status of an individual. Possible reasons behind observed undernutrition among smartphone addicts include poor eating habits, skipping or delaying meals, and an insufficient intake of fruits and vegetables.[40] Moreover, as discussed, prolonged smartphone use may be associated with exposure to judgments on physical appearance and unrealistic beauty standards, potentially leading to the development of body dissatisfaction and weight loss behaviors.[37,41] Further research is warranted to explicate the relationship between smartphone use and nutritional status among different sociodemographic groups.

There are some limitations of the present study that should be mentioned. First, the sample size of the study is small, and the study should be replicated on larger sample sizes and different populations before generalization. Further, the proportion of females in the study sample was higher than that of males, which ideally should have been equal. Nevertheless, the odds ratio analysis was adjusted for sex. Lastly, the screening for SA was done through a self-reported questionnaire (SAS-SV). Though SAS-SV is a widely used and cross-culturally validated tool, in-depth interviews, along with SAS-SV, would have yielded richer data.

Conclusion

One in every four participants was found to be addicted to smartphones in the present study. SA prevalence was significantly higher among males and undergraduate students than among females and postgraduate/MPhil/PhD students, respectively. Though SA was not associated with obesity in the present study, it was found to be associated with the risk of being underweight, indicating a relationship between smartphone use and nutritional status among young adults. Given that smartphones are a rather recent addition to our social lives, cultural practices and norms regarding the healthy usage of such devices are still in the formative phase. There is an urgent need to take up studies exploring the health implications of smartphone use/overuse and create awareness regarding the healthy use of smartphones among the masses so that potentially adverse health outcomes can be averted.

Ethics approval

The study was approved by the Departmental Ethics Committee, Department of Anthropology, University of Delhi, Delhi-110007, India (Ref No: Anth/2022-23/526 and Ref No: Anth/2022-23/532).

Informed consent

Informed written consent, typed in English, was obtained from each participant before recruitment.

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Conflicts of interest

There are no conflicts of interest.

References

1. Ting CH, Chen YY. Smartphone addiction. In: Essau CA, Delfabbro PH,

editors. Adolescent Addiction. 2nd ed. London: Academic Press; 2020. p. 215-40.
2. Al-Barashdi HS, Bouazza A, Jabur NH. Smartphone addiction among university undergraduates: A literature review. Sci Rep 2015;4:210-25.
3. Sohn SY, Rees P, Wildridge B, Kalk NJ, Carter B. Prevalence of problematic smartphone usage and associated mental health outcomes amongst children and young people: A systematic review, meta-analysis and GRADE of the evidence. BMC Psychiatry 2019;19:356.
4. Candussi CJ, Kabir R, Sivasubramanian M. Problematic smartphone usage, prevalence and patterns among university students: A systematic review. J Affect Disord 2023;14:100643.
5. Gangadharan N, Borle AL, Basu S. Mobile phone addiction as an emerging behavioral form of addiction among adolescents in India. Cureus 2022;14:e23798. doi: 10.7759/cureus.23798.
6. Ammati R, Kakunje A, Karkal R, Nafisa D, Kini G, Chandrashekaran P. Smartphone addiction among students of medical university in South India: A cross-sectional study. Ann Int Med Dent Res 2018;4:1-4.
7. Davey S, Davey A. Assessment of smartphone addiction in Indian adolescents: A mixed method study by systematic-review and meta-analysis approach. Int J Prev Med 2014;5:1500-11.
8. Jain P, Gedam SR, Patil PS. Study of smartphone addiction: Prevalence, pattern of use, and personality dimensions among medical students from rural region of central India. Open J Psychiatry Allied Sci 2019;10:132-8.
9. Eitivipart AC, Viriyarojanakul S, Redhead L. Musculoskeletal disorder and pain associated with smartphone use: A systematic review of biomechanical evidence. Hong Kong Physiother J 2018;38:77-90.
10. Ahmed HO, Marif MA, Omer MA, Hamasur AF, Ahmed SH, Abddalqadir KM. The life styles causing overweight or obesity: Based on 5 years of experience in two centers in Sulaimani Governorate, Kurdistan Region/Iraq. Int J Surg Open 2018;11:22-9.
11. Brodersen K, Hammami N, Katapally TR. Is excessive smartphone use associated with weight status and self-rated health among youth? A smart platform study. BMC Public Health 2023;23:234.
12. Blüher M. Obesity: Global epidemiology and pathogenesis. Nat Rev Endocrinol 2019;15:288-98.
13. Yadav N, Chaudhary V, Saraswathy KN, Devi NK. Vitamin intake in obesity and hypertension: A population-based study from Haryana, North India. Clin Epidemiology Glob Health 2022;8:101178.
14. International Institute for Population Sciences. National Family Health Survey (NFHS-5). Mumbai: IIPS; 2021. Available from: http://rchiips.org/nfhs/NFHS-5_FCTS/India.pdf. [Last accessed on 2022 Dec 05].
15. Venkatrao M, Nagarathna R, Majumdar V, Patil SS, Rathi S, Nagendra H. Prevalence of obesity in India and its neurological implications: A Multifactor analysis of a nationwide cross-sectional study. Ann Neurosci 2020;27:153-61.
16. Ahirwar R, Mondal PR. Prevalence of obesity in India: A systematic review. DiabetesMetab Syndr 2019;13:318-21.
17. Cheng HL, Medlow S, Steinbeck K. The health consequences of obesity in young adulthood. Curr Obes Rep 2016;5:30-7.
18. Tayhan Kartal F, Yabancı Ayhan N. Relationship between eating disorders and internet and smartphone addiction in college students. Eat Weight Disord 2021;26:1853-62.
19. Alpaslan AH, Koçak U, Avci K, Uzel Taş H. The association between internet addiction and disordered eating attitudes among Turkish high school students. Eat Weight Disord 2015;20:441-8.
20. Grimaldi-Puyana M, Fernández-Batanero JM, Fennell C, Sañudo B. Associations of objectively-assessed smartphone use with physical activity, sedentary behavior, mood, and sleep quality in young adults: A cross-sectional study. Int J Environ Res Public Health 2020;17:3499.
21. Xiang MQ, Lin L, Wang ZR, Li J, Xu Z, Hu M. Sedentary behavior and problematic smartphone use in Chinese adolescents: The moderating role of self-control. Front Psychol 2020;10:3032.
22. Meng SQ, Cheng JL, Li YY, Yang XQ, Zheng JW, Chang XW, *et al*. Global prevalence of digital addiction in general population: A systematic review and meta-analysis. Clin Psychol Rev 2022;92:102128.
23. Aggarwal H, Kaur H, Saklani R, Saba N, Choudhary S, Dogra S, *et al*. Prevalence of obesity and associated hypertension and diabetes in Delhi, metropolitan city of India. India J Med Specialities 2015;6:82-7.
24. Kwon M, Kim DJ, Cho H, Yang S. The smartphone addiction scale: Development and validation of a short version for adolescents. PLoS One 2013;8:e83558.
25. Misra A, Chowbey P, Makkar BM, Vikram NK, Wasir JS, Chadha D, *et al*. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. J Assoc Physicians India 2009;57:163-70.
26. Renuka K, Gopalakrishnan S, Umadevi R. Prevalence of smartphone addiction in an urban area of Kanchipuram district, Tamil Nadu: A cross sectional study. Int J Med 2019;6:4218.
27. Chen B, Liu F, Ding S, Ying X, Wang L, Wen Y. Gender differences in factors associated with smartphone addiction: A cross-sectional study among medical college students. BMC Psychiatry 2017;17:1-9.
28. Alosaimi FD, Alyahya H, Alshahwan H, Al Mahyijari N, Shaik SA. Smartphone addiction among university students in Riyadh, Saudi Arabia. Saudi Med J 2016;37:675-83.
29. Ghogare AS, Aloney SA, Vankar GK, Bele AW, Patil PS, Ambad RS. A cross-sectional online survey of an impact of COVID-19 lockdown on smartphone addiction and nomophobia among undergraduate health sciences students of a rural tertiary health-care center from Maharashtra, India. Indian J Psychiatry 2022;6:27.
30. Aljomaa SS, Qudah MF, Albursan IS, Bakhiet SF, Abduljabbar AS. Smartphone addiction among university students in the light of some variables. Comput Human Behav 2016;61:155-64.
31. Tang CS, Koh YW, Gan Y. Addiction to internet use, online gaming, and online social networking among young adults in China, Singapore, and the United States. Asia Pac J Public Health 2017;29:673-82.
32. Wang A, Wang Z, Zhu Y, Shi X. The prevalence and psychosocial factors of problematic smartphone use among Chinese college students: A three-wave longitudinal study. Front Psychol 2022;13:1476.
33. De-Sola Gutiérrez J, Rodríguez de Fonseca F, Rubio G. Cell-phone addiction: A review. Front Psychiatry 2016;7:175.
34. Alimoradi Z, Lotfi A, Lin CY, Griffiths MD, Pakpour AH. Estimation of behavioral addiction prevalence during COVID-19 pandemic: A systematic review and meta-analysis. Curr Addict Rep 2022;12:1-32.
35. Alhazmi AA, Alzahrani SH, Baig M, Salawati EM, Alkatheri A. Prevalence and factors associated with smartphone addiction among medical students at King Abdulaziz University, Jeddah. Pak J Med Sci 2018;34:984-8.
36. Subramani P, Mohan A. Association between smartphone addiction and body mass index amongst dental students. J Oral Heal Community Dent 2019;13:73-6.
37. Algahtani RA, AlSaadi ZS, Al-Qahtani ZA, Al-Garni AM, Shati AA, Malik AAM, *et al*. Smartphone use and its association with body image distortion and weight loss behaviours among adolescents in Saudi Arabia. Technol Health Care 2023. doi: 10.3233/THC-230756.
38. Mohanty S, Sahoo J, Panigrahi SK, Epari V, Yasobant S, Samantsinghar P. Prevalence, patterns, and predictors of yoga practice among adults in an urban population in Eastern India. Int J Yoga Ther 2021;31:Article_7. doi: 10.17761/2021-D-20-00022.
39. Wiklund E, Jonsson E, Coe AB, Wiklund M. 'Strong is the new skinny': Navigating fitness hype among teenagers in northern Sweden. Sport Educ Soc 2019;24:441-54.
40. Ryu S, Jang H, Oh H. Smartphone usage patterns and dietary risk factors in adolescents. J Nutr 2022;152:2109-16.
41. Kwon S, Kim R, Lee JT, Kim J, Song S, Kim S, *et al*. Association of smartphone use with body image distortion and weight loss behaviors in Korean adolescents. JAMA Netw Open 2022;5:e2213237. doi: 10.1001/jamanetworkopen. 2022.13237.

Supplementary Table 1: Correlation and association between SA score and obesity parameters

Obesity parameters	Correlation coefficient	*P*	β±SE	*P*
BMI	0.010	0.883	1.122±7.593	0.883
WC	0.036	0.573	0.154±0.273	0.573
WHR	0.027	0.675	0.001±0.003	0.675

β=beta coefficient; SE=standard error; BMI=body mass index; WC=waist circumference; WHR=waist-hip ratio