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Research article

Gender difference in metabolic syndrome and quality of life among elderly people in Noakhali, Bangladesh

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ABSTRACT

Background: Metabolic syndrome (MetS) is a cluster of metabolic abnormalities that significantly heighten the risk of non-communicable diseases, affecting the quality of life (QOL) of millions, including the elderly. Hence, the study aims to assess the prevalence of MetS and its impact on QOL among elderly population, with a focus on gender differences.
Methods: A cross-sectional study was conducted involving 400 elderly participants sought care at Noakhali General Hospital, Noakhali, Bangladesh. MetS was diagnosed based on National Cholesterol Education Program's (NCEP) Adult Treatment Panel (ATP) III criteria, while QOL was assessed using the brief version of the World Health Organization's QOL (WHOQOL-BREF) tool.
Results: Results revealed that over 70 % of the elderly participants had MetS, with a significantly higher prevalence among females (79.2 %) compared to males (66.7 %). Gender disparities were also evident in QOL scores, with males reporting better outcomes across all domains—physical, psychological, social, and environmental. Multiple linear regression analysis indicated that MetS negatively impacted the overall QOL for both genders, with more pronounced effects observed in females.
Conclusion: The findings underscore the necessity of gender-specific interventions targeting MetS management to improve the overall well-being of the elderly.

1. Introduction

Metabolic syndrome (MetS) refers to a cluster of conditions, including high blood pressure, raised triglyceride levels, low high-density lipoprotein (HDL) cholesterol, high blood glucose, and abdominal obesity [1]. MetS significantly contributes to the incidence of non-communicable diseases, including diabetes, cardiovascular diseases, chronic renal diseases, etc., which leads to an estimated 41 million deaths annually across the world [2]. The global prevalence of MetS has risen in recent decades, affecting around a quarter of the world's population and contributing to 7 % of total mortality [3]. Variations in diet, inactivity, urbanization, industrial development, and genetic susceptibility contribute significantly to the pervasiveness of MetS and this problem is severe in many developed and developing nations [4].

Quality of life (QOL), as defined by World Health Organization (WHO), encompasses how individuals perceive their place in society within the context of cultural values and norms and their aspirations, expectations, and concerns [5]. It is a comprehensive concept that intertwines physical health, mental well-being, autonomy, social connections, personal convictions, and interactions with the environment's significant elements [6]. For elderly individuals, QOL is particularly important, as it directly impacts their ability to live

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List of abbreviations

ATP	Adult Treatment Panel
BS	Bachelor of Science
BMI	Body mass index
FCS	Food consumption score
HDL	High-density lipoprotein
MetS	Metabolic syndrome
MNA	Mini nutrition assessment
MNA-SF	Mini nutritional assessment - Short form
NCEP	National Cholesterol Education Program
NCDs	Non-communicable diseases
PASE	Physical activity scale for the elderly
QOL	Quality of life
SNAQ	Simplified nutrition appetite questionnaire
SD	Standard deviation
WFP	World Food Programme
WHO	World Health Organization
WHOQOL-BREF	Brief version of the World Health Organization's QOL

independently and maintain a sense of dignity and purpose. Traditional health measures often focus on morbidity and mortality; however, for the elderly, the QOL is just as crucial as longevity [7].

Studies have shown that individuals with MetS generally experience poorer QOL [8–10]. This is particularly concerning for the elderly, who may already be dealing with age-related health issues and a decline in physical and cognitive functions [7]. The impact of MetS on QOL in the elderly is multifaceted. Physically, MetS can lead to chronic conditions such as diabetes, cardiovascular diseases, and stroke, which significantly impair mobility and independence [8]. Mentally, the stress and anxiety associated with managing multiple health conditions can lead to depression and a decline in mental health [9]. Socially, the limitations imposed by MetS can reduce participation in social activities, leading to isolation and loneliness [11]. These factors collectively contribute to a diminished QOL among the elderly.

Worldwide, the average lifespan has increased, and the number of elderly populations is growing. Bangladesh has also witnessed significant demographic shifts with an increase in life expectancy, and the people aged 60 years and above, is projected to increase from 8 % in 2021 to 11.5 % by 2030 and 21.5 % by 2050 [12]. Yet, this increment is accompanied by a surge in non-communicable diseases (NCDs) among the elderly, posing a substantial public health challenge. The QOL of older people gradually declines with age [13], and the prevalence of MetS rises concurrently due to age-related metabolic changes, hormone imbalances, sedentary lifestyles, poor diets, and genetic predispositions [11,14].

The situation in Bangladesh presents unique challenges and opportunities when addressing MetS and its impact on QOL among the elderly. As the population ages and urbanization accelerates, traditional lifestyle practices are increasingly replaced by sedentary behaviors and unhealthy dietary patterns. These changes are contributing to a rise in non-communicable diseases, including MetS, among the elderly. Despite the growing burden of these diseases, research focusing specifically on the relationship between MetS and QOL among elderly population in Bangladesh remains limited. This gap in the literature is significant, as the socio-economic and cultural context in Bangladesh may influence both the prevalence of MetS and its impact on QOL among older adults. Consequently, there is an urgent need for studies that explore these relationships, providing data that can inform public health policies and interventions tailored to the elderly in Bangladesh. Hence, the present study aims to evaluate the MetS and QOL among older people in Noakhali district, Bangladesh, and to assess whether these attributes and their association vary according to gender.

2. Methods

2.1. Study design, and setting

A cross-sectional study was designed among elderly individuals who sought care at the outpatient center of Noakhali General Hospital, Noakhali, Bangladesh, between January and March 2024. This study defined an elderly individual as a person aged 60 years or older, following the National Policy on Older Persons 2013 in Bangladesh [15]. The inclusion criteria were as follows: (1) living in Noakhali district for at least one year, and (2) aged ≥60 years. Older adults with critical illness and those who disagreed to give consent were excluded from the study.

2.2. Participants

The sample size of the study was calculated using Cochran's formula of $z^2p(1\text{-}p)/d^2$ [16]. Here, z was the value of the normal distribution (at 95 % confidence level, it was 1.96); p was the expected prevalence, which was assumed 50 % in this case; d value around 0.05 was the tolerable standard error. According to this equation, the total sample size was 400 considering around 4 % attrition rate to satisfactorily accommodate participant refusal, drop outs, or withdrawals during the study execution. This rate was chosen based on the prior study conducted in similar settings where minimal participant loss was observed [17]. This adjustment ensured that the final sample size would remain sufficient to provide reliable and generalizable results. However, simple random sampling method was utilized in this study to approach 405 elderly and information was collected from 400 individuals (response rate >98 %).

2.3. Development of questionnaire

This study has been conducted using a structured questionnaire that was prepared based on previous literatures [9,17–20]. Two public health experts reviewed the draft questionnaire. Based on the suggestions and comments of the reviewers, the questionnaire was modified. A pilot study was also carried out with twenty-five participants (around 5 % of the total sample size) to identify the face validity and reliability of the questionnaire. Finally, a pretested and standardized questionnaire was prepared for data collection.

2.3.1. Socio-demographic information

The participants were asked about their socioeconomic and demographic characteristics, such as gender, age, marital status, family size, occupation, education, household income, etc.

2.3.2. Anthropometric and biochemical measures

The anthropometric measurements included weight, height, waist circumference, and mid-upper arms circumferences. Weight was measured using a digital weighing scale (SECA 813, Hamburg, Germany) to the nearest 0.1 kg and height was measured using a portable stadiometer (SECA 213, Hamburg, Germany) to the nearest 0.1 cm. The waist circumference was measured with a non-elastic tape midway between the lower rib margin and the iliac crest at the end of a gentle expiration. The mid-upper arm circumference was measured with a non-elastic tape midway between the acromion and the olecranon process on the right arm with the hanging loosely at the side of the body. Blood pressure was measured three times to obtain the average blood pressure using a mercury sphygmomanometer, in a seated position, and after a 15-min rest [21]. Fasting blood glucose (mg/dL), serum HDL (mg/dL), total cholesterol (mg/dL), and triglycerides (mg/dL) were recorded from the routine laboratory test results.

2.3.3. Physical activity

Physical activity was examined by applying the Physical Activity Scale for the Elderly (PASE). The PASE is a reliable and a well-validated 12-item self-report questionnaire that assesses the intensity (weight assigned to each activity), frequency (days/week), and duration (hours/day) of physical activity over the past week. The total PASE score ranges from 0 to 793, with higher scores reflecting greater physical activity levels [22].

2.3.4. Diet and nutrition related characteristics

The Food Consumption Score (FCS) questionnaire was used for the measurement of dietary behavior. The Simplified Nutrition Appetite Questionnaire (SNAQ), and the Mini Nutrition Assessment (MNA) tool was used for the measurement of Nutrition-related attributes of the participants.

The FCS measures the variety and frequency of the food groups ingested in the preceding seven days and the relative nutritional value of the food groups consumed. Foods were split into nine food groups, and the weight corresponding to each food group was multiplied by how often it was eaten in the last seven days. The World Food Programme (WFP) categorized food consumption scores as poor (0-21), borderline (21.5–35), or acceptable (≥35), where the overall consumption of oil and sugars was frequent among all study participants [23].

Simplified Nutritional Appetite Questionnaire (SNAQ) is another validated screening tool for nutritional assessment [17]. The questions were divided into four areas: appetite, satiety, taste of food, and number of meals a person usually has daily. The total score was 4–20 points and a cutoff level of ≤14 was considered as a risk of malnutrition [24].

The Mini Nutrition Assessment (MNA) is a valid tool for screening and assessing malnutrition among the elderly population worldwide [25] and the Mini Nutritional Assessment - Short Form (MNA-SF) was employed in this study. This questionnaire contained six items: decreased food intake, weight loss during the last three months, mobility, recent psychological stress or acute disease, neuropsychological problems, and the Body Mass Index (BMI). The maximum score was 14, and a score of 0–7, 8–11 and 12–14 considered malnourished, at risk of malnutrition and normal nutritional status, respectively [26].

2.3.5. Metabolic syndrome (MetS)

The criteria for Asian by the Adult Treatment Panel (ATP) III of the National Cholesterol Education Program (NCEP) was utilized to define of metabolic syndrome (MetS) [1]. Accordingly, three or more of the following risk factors must be present in a person, including - 1) abdominal obesity as waist circumference >90 cm for male and >80 cm for female, 2) high triglyceride as ≥150 mg/dL or currently taking medication, 3) low HDL cholesterol as <40 mg/dL for men or <50 mg/dL for women, or currently taking medication, 4) high blood pressure as ≥130/85 mmHg or currently taking medication, and 5) high fasting glucose ≥110 mg/dL or currently taking medication.

2.3.6. Quality of life (QOL)

The quality of life (QOL) was assessed utilizing the brief version of the World Health Organization's QOL (WHOQOL-BREF). It is a standardized tool that can be used in any culture [5]. The WHOQOL-BREF is a self-report measure with 2 general questions (on QOL and satisfaction with health) and 24 specific questions evaluating four QOL areas: Physical (7 items), Psychological (6 items), Social Relationships (3 items), and Environmental (8 items). This tool applies a scoring system assigned to each question, starting from 1 (very poor/very dissatisfied/none/never) to 5 (very good/very satisfied/extremely/always). The domain scores were transformed to a scale ranging from 0 to 100 and a higher score indicated a more positive perception of QOL [6].

2.4. Data collection

The authors, with the help of some final year Bachelor of Science (BS) students, approached the elderly seeking care at Noakhali General Hospital. The objectives of study, anticipated benefits, and potential risks of participating were clearly explained to them to encourage active participation and cooperation before getting oral and written consent. They were also assured of anonymity and confidentiality and given the opportunity to skip interviews at any stage of the study. Approval by the ethical committee of the Faculty of Science, Noakhali Science and Technology University (reference number: NSTU/SCI/EC/2023/199) was obtained before conducting the study. Finally, information was gathered from individuals who consented to join the study through face-to-face interviews, which took approximately 20 min to complete.

2.5. Statistical analysis

The collected data were analyzed using Statistical Package for the Social Sciences (SPSS, vs. 27) for Windows (SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test, a widely accepted method for assessing normality, was performed for the continuous variables to determine the normality of the distribution. For the continuous variables, mean and standard deviation (SD), and for categorical variables, frequency and percentage was used where applicable. The chi-square test and *t*-test were also applied for categorical and continuous data, respectively. Pearson's correlation was conducted to ascertain the relationship among domains of QOL. In this study, no missing value was noticed for any variables, and hence, no further step (i.e., single imputation, multiple imputation, listwise deletion, or others) was employed to address this issue.

A multiple linear regression was employed to identify the association of socio-demographic and related characteristics with the overall QOL of the participants. In this model, a purposeful selection of covariates was conducted based on prior research and theoretical relevance. All potential variables were entered into the model in a single step and analyzed using "Enter" method. The association between individual components of MetS and overall QOL of the participants was also assessed utilizing the multiple linear regression model. Only the variables that were significantly associated with overall QOL of the participants in the previous model were entered in this model. For all the models, the assumptions of the multiple linear regression models (i.e., normality, homoscedasticity of variances, independence, and linearity of the residuals) were tested. The presence of influential observations on the estimates of regression results were also assessed using various statistics and diagnostics, such as Cook's distance (cutoff value > 1), leverage measures (cutoff value $> 2p/n$, where n represents the sample size and p the number of parameters), and DfFits values (cutoff value >

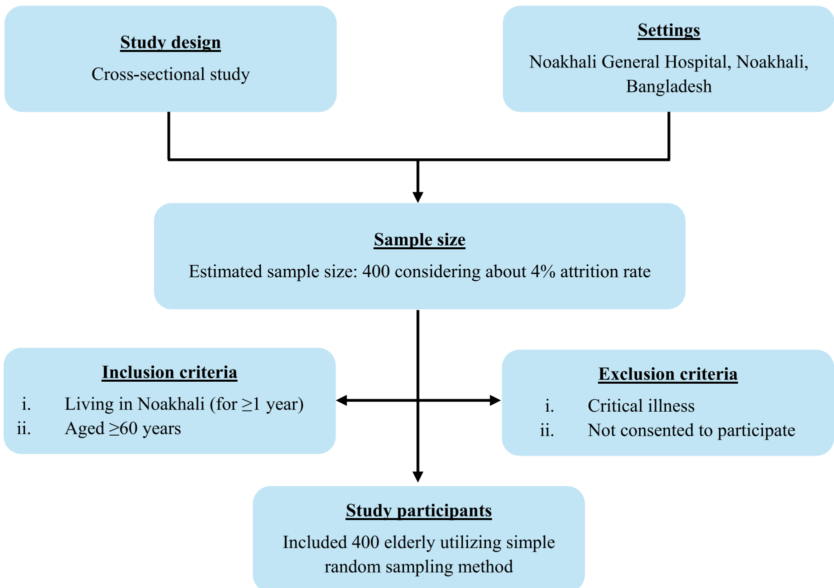

Fig. 1. Flow chart of study participants selection.

$2\sqrt{[p/n]}$, where n represents the sample size and p the number of parameters). A p-value of <0.05 (two-tailed test) was defined as statistically significant for all tests.

3. Results

The study involved 400 elderly participants and the participants selection process is illustrated in Fig. 1. Of them, 198 were males, and 202 were females. A p-value greater than 0.05 was achieved in Shapiro-Wilk test, indicating that the data did not deviate significantly from a normal distribution and also ensured the robustness of the normality assumption, which is critical for parametric analyses conducted in this study. Table 1 reveals the socio-demographic as well as nutrition-related characteristics of the participants and the gender differences regarding these attributes. Age distribution differed significantly by gender ($p < 0.001$), with a higher percentage of females in the 60–69 years of age group (89.1 % vs. 75.8 % of males) and a higher percentage of males in the age group of ≥70 years. Males were more formally educated (secondary and tertiary educated) than females ($p < 0.001$). Males were more self-employed than females (76.3 % vs 14.9, $p < 0.001$), whereas the majority of the females had no cash income compared to males (78.2 % vs 2.5 %, $p < 0.001$). The prevalence of currently married was significantly higher among males (83.8 % vs 66.3 %, $p < 0.001$), and females were significantly more divorced, separated, or widowed than males (32.7 % vs. 16.2 %, $p < 0.001$). Besides, no significant gender differences were observed regarding residence, monthly household income, and number of household members ($p > 0.05$).

Table 1
Characteristics of the participants.

Variables	Total (%)	Male (%)	Female (%)	p-value*
Age (years)				
60–69	330 (82.5)	150 (75.8)	180 (89.1)	<0.001
70–79	62 (15.5)	40 (20.2)	22 (10.9)	
≥80	8 (2.0)	8 (4.0)	0 (0)	
Residence				
Rural	225 (56.3)	120 (60.6)	105 (52.0)	0.082
Urban	175 (43.7)	78 (39.4)	97 (48.0)	
Level of education				
No formal schooling	43 (10.8)	15 (7.6)	28 (13.9)	<0.001
Primary	145 (36.2)	60 (30.3)	85 (42.1)	
Secondary	152 (38.0)	80 (40.4)	72 (35.6)	
Tertiary	60 (15.0)	43 (21.7)	17 (8.4)	
Occupation				
Service	56 (14.0)	42 (21.2)	14 (6.9)	<0.001
Self-employed	181 (45.3)	151 (76.3)	30 (14.9)	
No cash income	163 (40.7)	5 (2.5)	158 (78.2)	
Marital status				
Never married	2 (0.5)	0 (0.0)	2 (1.0)	<0.001
Currently married	300 (75.0)	166 (83.8)	134 (66.3)	
Divorced/separated/widowed	98 (24.5)	32 (16.2)	66 (32.7)	
Monthly household income (BDT)				
≤30000	102 (25.5)	48 (24.2)	54 (26.7)	0.568
>30000	298 (74.5)	150 (75.8)	148 (73.3)	
Household member				
1–4	132 (33.0)	62 (31.3)	70 (34.7)	0.383
5–8	261 (65.2)	134 (67.7)	127 (62.8)	
>8	7 (1.8)	2 (1.0)	5 (2.5)	
Food consumption score (FCS)				
0-21 (Poor)	0 (0.0)	0 (0)	0 (0)	0.160
21.5–35 (Borderline)	2 (0.5)	0 (0)	2 (1.0)	
≥35 (Acceptable)	398 (99.5)	198 (100.0)	200 (99.0)	
SNAQ score				
≤14 (Risk of malnutrition)	195 (48.8)	91 (46.0)	104 (51.5)	0.269
>15 (Well-nourished)	205 (51.2)	107 (54.0)	98 (48.5)	
MNA score				
0-7 (Malnourished)	24 (6.0)	12 (6.1)	12 (5.9)	0.120
8-11 (At risk of malnutrition)	182 (45.5)	100 (50.5)	82 (40.6)	
12-14 (Normal nutritional status)	194 (48.5)	86 (43.4)	108 (53.5)	
BMI (kg/m^2)				
<18.5 (Undernutrition)	5 (1.3)	4 (2.0)	1 (0.5)	0.391
18.5–22.9 (Normal nutritional status)	106 (26.4)	56 (28.3)	50 (24.8)	
23.0–24.9 (Overweight)	149 (37.2)	73 (36.9)	76 (37.5)	
25.0–29.9 (Pre-obese)	125 (31.3)	56 (28.3)	69 (34.2)	
≥30 (Obese)	15 (3.8)	9 (4.5)	6 (3.00)	
PASE score (mean ± SD)	86.67 ± 49.9	91.3 ± 51.6	82.2 ± 49.2	0.067

BDT: Bangladeshi taka, SD: Standard deviation. *Chi-square test by gender, BMI: Body mass index, MNA: Mini nutritional assessment, SNAQ: Simplified nutritional appetite questionnaire, PASE: Physical activity scale for the elderly, *Chi-square test by gender.

No significant gender differences were observed in terms of their FCS, SNAQ score, MNA score, BMI and PASE score ($p > 0.05$). Almost all participants had acceptable FCS. About half of the older adults were at risk of malnutrition, having SNAQ scores ≤14 and/or MNA ≤11. Additionally, over two-thirds of the participants were overweight and obese having a BMI ≥23.0 kg/m^2.

Table 2 depicts the prevalence of MetS risk factors among the participants. The prevalence of abdominal obesity and low HDL cholesterol levels was significantly ($p < 0.001$) higher among females as compared to males. However, no significant differences were observed between male and female elderly regarding the prevalence of high triglyceride, high blood pressure, and high fasting glucose ($p > 0.05$). Around 70 % (68.6 %–77.4 %) of the participants had metabolic syndrome, having more than three risk factors, where the prevalence was significantly higher among the female elderly compared to their male counterparts [79.2 % (73.6 %–84.9 %) vs. 66.7 % (60.0 %–73.3 %)].

Table 3 shows the distribution of QOL scores in each domain among the participants. In each of the domains (physical, psychological, social relationship, and environment), male participants exhibited significantly higher QOL scores than females ($p < 0.001$).

Table 4 delineates the correlation among the four domains of QOL. It was revealed that all the domains of QOL were significantly ($p < 0.01$) correlated to each other, indicating that the changes in one domain of QOL were likely to be associated with the changes in different domains.

Table 5 shows a multiple linear regression to determine the association of socio-demographic and related characteristics with the participants' overall QOL. The assumptions of the regression models (i.e., normality, homoscedasticity of variances, and linearity of the residuals) were provided in the Supplementary Fig. S1 where, the homoscedasticity denotes the assumption that the spread of data points (variability) is roughly the same across all levels of an independent variable. From the figure, the residuals were approximately normally distributed (a and b) and no specific pattern was observed in the scatterplot (c). The Durbin-Watson test used to check the independence of residuals gave a value of 1.711, which was close to 2. Accordingly, the data passed the assumptions of the regression and, hence, the results were valid. Additionally, the assessment of influential observations on the estimates of regression results are summarized in Supplementary Table S1. Based on the diagnostic measures, it was concluded that there were no influential observations that substantially affected the estimates of the regression slopes or coefficients. SNAQ score, PASE score, and MetS were significantly associated with overall QOL among the elderly. Gender differences were also observed for overall QOL. QOL of the male elderly was significantly associated with household members, MNA score, PASE score, and MetS. With the increase in household members and MetS, QOL decreases by 1.902 and 10.444 units, respectively ($p < 0.05$). In addition, with a unit increase in nutritional status (MNA score) and physical activity (PASE score), QOL increases by 1.123 and 0.145 units, respectively ($p < 0.05$). On the other hand, FCS ($b = 0.178$, $p = 0.012$) and PASE score ($b = 0.135$, $p < 0.001$) were significantly positively and MetS was significantly negatively ($b = -15.475$, $p < 0.001$) associated with the QOL of the female participants.

Table 6 shows the association between the individual components of the MetS and the overall QOL of the participants. Supplementary Figs. S2–S6 provide the assumptions of the regression models. Like previous model, these models also satisfied the assumptions and the results could be considered valid. Furthermore, the results of influential observations assessment also demonstrated no impact of influential observations on regression results (Supplementary Tables S2–S6). Overall, all the individual components of the MetS were significantly negatively associated with QOL of the elderly ($p < 0.05$). Gender differences were also noted and high triglyceride, low HDL cholesterol and high blood pressure were associated with overall QOL in male elderly. However, high triglyceride, low HDL cholesterol, high blood pressure and high fasting glucose were associated with overall QOL in female elderly.

4. Discussion

The present study illustrates the gender disparities in metabolic syndrome (MetS) and quality of life (QOL) among the elderly. The

Table 2
Prevalence of metabolic syndrome and risk factors for the metabolic syndrome among the participants.

Risk factors	Total (%)	Male (%)	Female (%)	p-value*
Abdominal Obesity				
No (WC ≤ 90 cm for Asian male and ≤80 cm for Asian female)	45 (11.3)	41 (20.7)	4 (2.0)	<0.001
Yes (WC > 90 cm for Asian male and >80 cm for Asian female)	355 (88.7)	157 (79.3)	198 (98.0)	
High triglyceride				
No (<150 mg/dL)	131 (32.7)	72 (36.4)	59 (29.2)	0.127
Yes (≥150 mg/dL)	269 (67.3)	126 (63.6)	143 (70.8)	
Low HDL cholesterol				
No (≥40 mg/dL for male and ≥50 mg/dL for female)	169 (42.2)	118 (59.6)	51 (25.2)	<0.001
Yes (<40 mg/dL for male and <50 mg/dL for female)	231 (57.8)	80 (40.4)	151 (74.8)	
High blood pressure				
No (<130/85 mmHg and no medication)	251 (62.7)	124 (62.6)	127 (62.9)	0.960
Yes (≥130/85 mmHg or current medication)	149 (37.3)	74 (37.4)	75 (37.1)	
High fasting glucose				
No (<110 mg/dL and no medication)	21 (5.3)	11 (5.6)	10 (5.0)	0.786
Yes (≥110 mg/dL or current medication)	379 (94.7)	187 (94.4)	192 (95.0)	
Metabolic syndrome				
No (<3 risk factors)	108 (27.0)	66 (33.3)	42 (20.8)	0.005
Yes (≥3 risk factors)	292 (73.0)	132 (66.7)	160 (79.2)	

WC: Waist circumference. *Chi-square test by gender.

Table 3
Distribution of quality of life (QOL) scores in each domain among the participants.

Domains of QOL	Total Mean (SD)	Male Mean (SD)	Female Mean (SD)	p-value*
Physical	46.8 (20.6)	51.7 (20.3)	42.1 (19.8)	<0.001
Psychological	47.3 (20.9)	51.5 (20.9)	43.0 (20.2)	<0.001
Social relationships	48.6 (24.6)	52.7 (23.3)	44.6 (25.3)	<0.001
Environment	48.8 (24.1)	54.1 (24.4)	43.7 (22.7)	<0.001
Overall QOL	56.3 (19.3)	60.9 (19.1)	51.7 (18.4)	<0.001

SD: Standard deviation. *Independent *t*-test by gender.

Table 4
Pearson's correlation among domains of quality of life (QOL).

Domains of QOL	Physical	Psychological	Social relationships	Environment
Physical	1			
Psychological	0.795[a]	1		
Social relationships	0.748[a]	0.796[a]	1	
Environment	0.746[a]	0.775[a]	0.755[a]	1

[a] Correlation is significant at the 0.01 level (2-tailed).

Table 5
Multiple linear regression analysis of overall quality of life (QOL) explained by socio-demographic, diet and nutrition related characteristics, physical activity, and MetS among the participants.

Variables	Total			Male			Female		
	b	95 % CI for *b*	p-value*	*b*	95 % CI for *b*	p-value*	*b*	95 % CI for *b*	p-value*
Age	−0.011	−0.321, 0.300	0.947	−0.163	−0.550, 0.225	0.409	0.233	−0.354, 0.819	0.435
Residence: urban	1.357	−1.672, 4.385	0.379	0.740	−3.593, 5.073	0.737	2.385	−1.875, 6.644	0.271
Level of education: primary	−1.940	−6.994, 3.113	0.451	−6.751	−15.094, 1.591	0.112	0.647	−5.839, 7.133	0.844
Level of education: secondary	−0.256	−5.475, 4.964	0.923	−3.742	−12.123, 4.639	0.380	1.353	−5.593, 8.300	0.701
Level of education: tertiary	0.304	−6.349, 6.958	0.928	−3.123	−12.855, 6.609	0.527	0.723	−9.210, 10.656	0.886
Occupation: self-employed	3.638	−1.348, 8.624	0.152	3.817	−2.130, 9.765	0.207	−4.712	−14.966, 5.542	0.366
Occupation: no cash income	0.170	−5.229, 5.569	0.951	1.736	−12.526, 15.999	0.810	0.796	−8.614, 10.206	0.868
Marital status: currently married	8.797	−11.742, 29.335	0.400	–	–	–	7.370	−14.664, 29.404	0.510
Marital status: divorced/separated/widowed	5.174	−15.527, 25.874	0.623	−0.750	−6.565, 5.065	0.799	2.557	−19.498, 24.612	0.819
Monthly household income	–	–	–	–	–	–	–	–	–
Household member	−0.986	−2.087, 0.114	0.079	−1.902	−3.647, −0.158	0.033	−0.693	−2.149, 0.764	0.349
FCS	0.054	−0.048, 0.156	0.297	−0.096	−0.250, 0.057	0.218	0.178	0.040, 0.316	0.012
SNAQ score	0.656	0.005, 1.308	0.048	0.651	−0.319, 1.622	0.187	0.367	−0.513, 1.247	0.412
MNA score	0.593	−0.107, 1.293	0.097	1.123	0.070, 2.176	0.037	0.360	−0.595, 1.316	0.458
BMI	−0.565	−1.163, 0.033	0.064	−0.739	−1.585, 0.108	0.087	−0.321	−1.174, 0.533	0.459
PASE score	0.148	0.114, 0.183	<0.001	0.145	0.096, 0.195	<0.001	0.135	0.085, 0.185	<0.001
MetS: yes	−12.552	−16.478, −8.626	<0.001	−10.444	−15.811, −5.078	<0.001	−15.475	−21.183, −9.766	<0.001

b: Unstandardized regression coefficient; BMI: Body mass index, CI: Confidence interval, FCS: Food consumption score, MetS: Metabolic syndrome, MNA: Mini nutritional assessment, PASE: Physical activity scale for the elderly, SE: Standard error. SNAQ: Simplified nutritional appetite questionnaire. *Multiple linear regression.

association of MetS and QOL was also assessed and evaluated to see whether gender impacts such an association. This study observed that more than two-thirds of the participants had at least three of the metabolic risk factors, and the prevalence was significantly higher among females (Table 2). Gupta et al. [27] reported about 21.6 % prevalence of MetS among the population aged 50–69 years in a nationwide survey in Bangladesh, and the prevalence was also higher in females than their male counterparts. The overall prevalence of MetS was observed at around 24.5 % among the rural older people of Bangladesh, where the occurrence of MetS was higher among females than males (27.5 % vs. 19.2 %) in the study of Bhowmik et al. [28]. The current study also observed that abdominal obesity and low HDL cholesterol level varied with gender, and females had higher frequency than males ($p < 0.001$) (Table 2). The observed high

Table 6
Multiple linear regression analysis of overall quality of life (QOL) explained by the individual components of the metabolic syndrome among the participants.

Variables	Total			Male			Female		
	b	95 % CI for *b*	p-value*	*b*	95 % CI for *b*	p-value*	*b*	95 % CI for *b*	p-value*
Abdominal obesity (WC > 90 cm for Asian male and >80 cm for Asian female)	−7.196	−11.993, −2.399	0.003	−4.667	−9.774, 0.439	0.073	2.115	−12.958, 17.188	0.782
High triglyceride (≥150 mg/dL)	−11.893	−15.478, −8.307	<0.001	−8.843	−14.655, −3.655	<0.001	−14.005	−18.688, −9.323	<0.001
Low HDL cholesterol (<40 mg/dL for male and <50 mg/dL for female)	−18.269	−21.457, −15.081	<0.001	−18.318	−22.728, −13.907	<0.001	−15.386	−20.748, −10.024	<0.001
High blood pressure (≥130/85 mmHg or current medication)	−6.561	−9.914, −3.209	<0.001	−8.430	−12.898, −3.961	<0.001	−5.292	−9.959, −0.625	0.026
High fasting glucose (≥110 mg/dL or current medication)	−9.897	−16.793, −3.000	0.005	−4.664	−13.953, 4.625	0.323	−15.654	−25.255, −6.053	0.002

b: Unstandardized regression coefficient; WC: Waist circumference. All linear regression models were adjusted for household member, food consumption score (FCS), Mini nutritional assessment (MNA) score, Physical activity scale for the elderly (PASE) score. *Multiple linear regression.

prevalence of MetS among elderly individuals, particularly females, underscores an urgent need for targeted public health initiatives, for example, education on healthy eating habits, regular physical activity, and periodic health check-ups to monitor metabolic health.

Elderly females above 60 were the subject of this study, a postmenopausal age that might pull up the prevalence of MetS higher than males. Menopause causes several physiological and biological changes; for example, redistribution of body fat results in abdominal obesity and insulin resistance, eventually increasing the risk of MetS [29]. The higher prevalence of low HDL cholesterol among elderly females than males could be due to their hormonal differences, notably lower estrogen levels during post-menopause, which adversely influence lipid metabolism (reduced HDL cholesterol) [30]. Furthermore, genetic factors and differences in fat distribution, with women typically having higher body fat percentages, play significant roles in these gender disparities in HDL cholesterol levels [29]. These findings highlight the needs for public health interventions that would focus on weight management programs particularly for the post-menopausal women to minimize the occurrences of abdominal obesity and low HDL cholesterol including culturally sensitive dietary counseling to promote low-calorie and nutrient-dense foods. However, MetS prevalence was found to be higher compared to the previous studies, irrespective of gender [27,28], which may be because of the subject selection from the outpatient departments of the hospital [31,32]. In addition, the discrepancies in prevalence might be due to the differences in ages, ethnicities, geography, socioeconomic, cultural, and lifestyle aspects, etc. [28,29].

This study found higher QOL scores among older adults (male: 51.5–54.1, female: 42.1–43.7) compared to the previous studies by Sarker et al. [12] and Uddin et al. [7] in Bangladesh. This substantial difference in QOL scores highlights the possible improvement in living conditions, healthcare access, or social support systems for older people over the years [33]. The disparity might also reflect methodological differences, such as variations in QOL measurement tools or differences in the characteristics of the study populations [34]. For instance, quality of life was measured by the short version of the WHOQOL-BREF in four domains (physical, psychological, social relationships, and environment) in this study, whereas Sarker et al. [12] utilized health-related quality of life using the EuroQol 5-Dimension (EQ-5D) tool. In addition, rural people with a 55 % occurrence of illiteracy were the study subjects in the study of Uddin et al. [7], where <40 % of the subjects of this study belonged to the urban setting, and only <14 % had no formal education which may be another reason of getting higher QOL score in this study.

Gender disparity in QOL was observed, with females reporting significantly lower QOL scores than males (Table 3), which is also evident in the previous study [12]. The lower QOL scores among females could be attributed to various factors, including socioeconomic conditions, cultural norms, and health disparities. Females may face greater economic insecurity and higher caregiving responsibilities, negatively impacting their QOL [35]. In addition, elderly females have to spend more time on household work and have to do more repetitive tasks every day than their male counterparts, which might be another reason why female elderly reported poorer QOL than male [36]. Moreover, 78.2 % of females reported having no cash income, but this prevalence was significantly lower among males (2.5 %) (Table 1). Furthermore, secondary and tertiary education was significantly higher among males than females (62 % vs 44 %) (Table 1). Thus, economic and educational constraints may also be responsible for their lower QOL than that of males.

The significant correlations among the four domains of QOL illustrate their interconnected nature (Table 4). This finding suggests that changes in one domain are likely to influence changes in others. Physical health could enhance psychological well-being and foster strong social relationships, thereby creating a supportive environment that may improve the overall QOL. These correlations emphasize the need for holistic interventions addressing multiple QOL aspects simultaneously. Integrated approaches, such as combining physical health initiatives with mental health support and community-building activities, can be particularly effective [37–39].

The complex interplay between various sociodemographic and health-related factors in determining the QOL among elderly individuals has been highlighted in Table 5. Among the sociodemographic variables, only household members were found to be a negative determinant of QOL for the elderly males. Most of the family in Bangladesh is male headed, thus, the potential stress and resource constraints related to the larger households may be a possible reason for this negative association among the male elderly

[35]. In this study, better nutritional status (measured by MNA) significantly enhanced QOL among the male elderly, highlighting the importance of maintaining good nutritional status to improve their quality of life. This finding is consistent with the previous studies. For example, a study on home-dwelling older adults aged 75 years by Kunvik et al. [40] and a research among long-term care elderly residents in Helsinki, Finland, by Salminen et al. [41] demonstrated that higher MNA scores were associated with better health-related quality of life and the association seemed to be stronger among male than female. Men have higher calorie and protein intake, greater red meat consumption, and high susceptibility to cardiovascular diseases that often lead them to impaired nutritional status and poor QOL compared to women [36,42,43].

The present study observed that FCS was positively correlated with QOL for female elderly. However, Yang et al. [44] reported that higher dietary indices were associated with higher QOL scores among both male and female rural elderly in China. Improved dietary quality among older people may enhance not only their physical health but also their mental well-being and functional status by preventing chronic diseases, maintaining muscle and bone health, boosting cognitive functions, and increasing life satisfaction, ultimately improving their QOL [45]. The gender differences observed in this study could be because older women may have higher nutritional needs and greater susceptibility to malnutrition than their male counterparts, significantly impacting their overall well-being [17,46].

Physical activity (measured by PASE) was positively and MetS was negatively associated with QOL for both male and female elderly (Table 5). Previous studies also reported physical activity as a positive [47–49] and MetS as a negative [8] predictor of QOL. Physical activity reduces chronic diseases and mental health problems; conversely, physical inactivity is a significant risk factor for non-communicable diseases [47]. Regular physical activity boosts cardiovascular health, lowers diabetes, helps in weight management, improves mood and cognitive function, reduces anxiety and depression, and ultimately reduces MetS [50]. A decrease in MetS further improves overall QOL [9,51] as confirmed by the findings of a negative association between MetS and QOL in this study.

Gender difference was noticed when the association of the individual components of MetS with QOL was assessed (Table 6). High triglyceride, low HDL cholesterol and high blood pressure were common predictors for both genders. Literature also identified low HDL cholesterol as a risk factor of MetS for elderly individuals irrespective of gender, which increases the chance of non-communicable diseases [52]. Besides, high fasting glucose was found to be a predictor of QOL for females only. Females exhibited a higher prevalence of high fasting glucose than males, which may be due to hormonal fluctuations, particularly insulin resistance linked to menopause. Post-menopausal hormonal changes exacerbate insulin resistance, affecting glucose regulation and thereby increasing fasting blood glucose levels [53]. Additionally, higher rates of abdominal obesity and physical inactivity in females than in males may contribute to impaired glucose metabolism. Genetic predispositions and differences in body fat distribution, with females typically having more visceral fat, further influence these disparities [52].

The above findings underscore the significance of integrating MetS screening into existing elderly health programs at primary healthcare centers. Furthermore, the policymakers should develop gender-sensitive health policies, such as subsidizing nutritional supplements for elderly women and supporting male caregivers through educational resources to reduce the disparities identified in this study.

4.1. Strengths and limitations

This study provides valuable insights into the gender disparities in the association of MetS and QOL among elderly people. This study used comprehensive and well-validated set of questionnaires and tools, such as the PASE, FCS, SNAQ and MNA which ensures the reliability and accuracy of the data collected. The inclusion of various demographic, anthropometric, and biochemical parameters also offer a holistic view of the participants' health status. The study's findings are significant for developing gender-specific health interventions and policies aimed at improving the overall well-being and QOL of the elderly population.

The study is limited by its cross-sectional design, which restricts the ability to establish causality. Additionally, the reliance on self-reported data for some variables, such as physical activity and dietary habits, may introduce recall bias and affect the accuracy of the findings. Furthermore, the study sample, being specific to a particular geographic region in Bangladesh, may limit the generalizability of the results to other populations.

5. Conclusion

The present study noted a high prevalence of MetS, affecting over 70 % of the elderly, with a higher incidence in females than males. Additionally, females exhibited a lower QOL scores across all domains (physical, psychological, social, and environmental) of QOL compared to their male counterparts. Regression analysis revealed negative associations between MetS and overall QOL for both genders of the elderly; however, the associations were more pronounced in females. These findings emphasize the necessity for gender-specific interventions targeting MetS risk factors to address these disparities and improve the overall well-being of the elderly population. Future research should focus on longitudinal studies to establish causality and explore the effectiveness of targeted public health policies and interventions tailored to the unique socio-economic and cultural context of Bangladesh.

CRediT authorship contribution statement

Marjia Sultana: Writing – original draft, Methodology, Conceptualization. **Md. Mehedi Hasan:** Writing – original draft, Data curation. **Towhid Hasan:** Writing – review & editing, Formal analysis, Conceptualization.

Data availability statement

Data will be made available on request.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

[1] M. Sultana, T. Hasan, L.C. Shill, N.H. Purba, A.I. Chowdhury, M. Rahman, et al., Menopausal status and metabolic syndrome among women with cardiovascular diseases: a cross-sectional study in Bangladesh, Current Medicine Research and Practice 11 (1) (2021) 18–22, https://doi.org/10.4103/cmrp.cmrp_8_21.
[2] WHO. Noncommunicable diseases Website: WHO [updated 2023- September- 16; cited 2024 26/02/2024]. Available from: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.
[3] A.R.D.S. Moura, S.M.R.S. da Paz, K.d.M.G. Frota, C.M.R.G. de, Carvalho Lifestyle associated with risk of metabolic syndrome in adults and the elderly, Nutrition 99 (2022) 111647, https://doi.org/10.1016/j.nut.2022.111647, 100.
[4] G. Gebreegziabiher, T. Belachew, K. Mehari, D. Tamiru, Magnitude and associated factors of metabolic syndrome among adult urban dwellers of Northern Ethiopia, Diabetes, Metabolic Syndrome and Obesity 14 (2021) 589–600, https://doi.org/10.2147/DMSO.S287281.
[5] C. Ower, G. Kemmler, T. Vill, C. Martini, A. Schmitt, B. Sperner-Unterweger, et al., The effect of physical activity in an alpine environment on quality of life is mediated by resilience in patients with psychosomatic disorders and healthy controls, Eur. Arch. Psychiatr. Clin. Neurosci. 269 (5) (2019) 543–553, https://doi.org/10.1007/s00406-018-0930-2.
[6] H. Malibary, M.M. Zagzoog, M.A. Banjari, R.O. Bamashmous, A.R. Omer, Quality of Life (QoL) among medical students in Saudi Arabia: a study using the WHOQOL-BREF instrument, BMC Med. Educ. 19 (2019) 1–6, https://doi.org/10.1186/s12909-019-1775-8.
[7] M.A. Uddin, P. Soivong, D. Lasuka, P. Juntasopeepun, Factors related to quality of life among older adults in Bangladesh: a cross sectional survey, Nurs. Health Sci. 19 (4) (2017) 518–524, https://doi.org/10.1111/nhs.12385.
[8] A. Marcos-Delgado, E. López-García, M. Martínez-González, J. Salas-Salvadó, D. Corella, M. Fitó, et al., Health-related quality of life in individuals with metabolic syndrome: a cross-sectional study, Medicina de Familia SEMERGEN 46 (8) (2020) 524–537, https://doi.org/10.1016/j.semerg.2020.03.003.
[9] Y.H. Lin, H.T. Chang, Y.H. Tseng, H.S. Chen, S.C. Chiang, T.J. Chen, et al., Changes in metabolic syndrome affect the health-related quality of life of community-dwelling adults, Sci. Rep. 11 (1) (2021) 20267, https://doi.org/10.1038/s41598-021-99767-y.
[10] Z. Hannoun, K. Harraqui, R.A.B. Ali, K. Tahiri, O.B. Smail, F.E. Arabi, et al., Study of the metabolic syndrome and physical activity in a population from Marrakesh, Morocco, The Pan African Medical Journal 38 (2021), https://doi.org/10.11604/pamj.2021.38.21.20219, 21-21.
[11] Y.H. Lin, Y.C. Chen, Y.C. Tseng, S.t. Tsai, Y.H. Tseng, Physical activity and successful aging among middle-aged and older adults: a systematic review and meta-analysis of cohort studies, Aging (Albany NY) 12 (9) (2020 7704), https://doi.org/10.18632/aging.103057.
[12] A.R. Sarker, Health-related quality of life among older citizens in Bangladesh, SSM - Mental Health 1 (2021) 100031, https://doi.org/10.1016/j.ssmmh.2021.100031.
[13] F.S. Hussenoeder, D. Jentzsch, H. Matschinger, A. Hinz, R. Kilian, S.G. Riedel-Heller, et al., Depression and quality of life in old age: a closer look, Eur. J. Ageing 18 (2021) 75–83, https://doi.org/10.1007/s10433-020-00573-8.
[14] K. Zhang, Y. Ma, Y. Luo, Y. Song, G. Xiong, Y. Ma, et al., Metabolic diseases and healthy aging: identifying environmental and behavioral risk factors and promoting public health, Front. Public Health 11 (2023) 1253506, https://doi.org/10.3389/fpubh.2023.1253506.
[15] GOB, National Policy on Older People 2013, Ministry of Social Welfare, Government of the People's Republic of Bangladesh, Dhaka, 2014.
[16] M. Sultana, S. Dhar, T. Hasan, L.C. Shill, N.H. Purba, A.I. Chowdhury, et al., Knowledge, attitudes, and predictors of exclusive breastfeeding practice among lactating mothers in Noakhali, Bangladesh, Heliyon 8 (10) (2022) e11069, https://doi.org/10.1016/j.heliyon.2022.e11069.
[17] A.H. Razon, M.I. Haque, M.F. Ahmed, T. Ahmad, Assessment of dietary habits, nutritional status and common health complications of older people living in rural areas of Bangladesh, Heliyon 8 (2) (2022) e08947, https://doi.org/10.1016/j.heliyon.2022.e08947.
[18] R.J. Gobbens, R. Remmen, The effects of sociodemographic factors on quality of life among people aged 50 years or older are not unequivocal: comparing SF-12, WHOQOL-BREF, and WHOQOL-OLD, Clin. Interv. Aging 14 (2019) 231–239, https://doi.org/10.2147/CIA.S189560.
[19] N.A.S.A. Aziz, N.I.M.F. Teng, M.K. Zaman, Geriatric nutrition risk index is comparable to the mini nutritional assessment for assessing nutritional status in elderly hospitalized patients, Clinical Nutrition ESPEN 29 (2019) 77–85, https://doi.org/10.1016/j.clnesp.2018.12.002.
[20] C.O. Akosile, C.K. Igwemmadu, E.C. Okoye, A.C. Odole, U.G. Mgbeojedo, A.A. Fabunmi, et al., Physical activity level, fear of falling and quality of life: a comparison between community-dwelling and assisted-living older adults, BMC Geriatr. 21 (2021) 1–9, https://doi.org/10.1186/s12877-020-01982-1.
[21] T. Hasan, M. Sultana, N.H. Purba, L.C. Shill, M. Rahman, M.A. Lashkar, et al., Assessment of risk factors among cardiovascular patients: a WHO STEPS approach in Bangladesh, Acta Sci. Health Sci. 45 (1) (2023) e61919, https://doi.org/10.4025/actascihealthsci.v45i1.61919.
[22] D.D. Callow, N.A. Arnold-Nedimala, L.S. Jordan, G.S. Pena, J. Won, J.L. Woodard, et al., The mental health benefits of physical activity in older adults survive the COVID-19 pandemic, Am. J. Geriatr. Psychiatr. 28 (10) (2020) 1046–1057, https://doi.org/10.1016/j.jagp.2020.06.024.
[23] D. Wiesmann, L. Bassett, T. Benson, J.F. Hoddinott, Validation of the World Food Programme's Food Consumption Score and Alternative Indicators of Household Food Security, International Food Policy Research Institute (IFPRI), Washington, D.C., 2015.

[24] S. Lau, K. Pek, J. Chew, J.P. Lim, N.H. Ismail, Y.Y. Ding, et al., The simplified nutritional appetite questionnaire (SNAQ) as a screening tool for risk of malnutrition: optimal cutoff, factor structure, and validation in healthy community-dwelling older adults, Nutrients 12 (9) (2020) 2885, https://doi.org/10.3390/nu12092885.

[25] M. Urgessa, The mini nutritional assessment tool's applicability for the elderly in Ethiopia: validation study, Peer Journal 10 (2022) e14396, https://doi.org/10.7717/peerj.14396.

[26] L. Risch, F. Hotzy, S. Vetter, S. Hiller, K. Wallimann, E. Seifritz, et al., Assessment of nutritional status and risk of malnutrition using adapted standard tools in patients with mental illness and in need of intensive psychiatric treatment, Int. J. Environ. Res. Publ. Health 20 (1) (2022), https://doi.org/10.3390/ijerph20010109.

[27] R.D. Gupta, R.J. Tamanna, M. Akonde, T. Biswas, P.A. Chakraborty, M.B. Hossain, Prevalence and associated factors of metabolic syndrome among Bangladeshi adults: evidence from a nation-wide survey, Diabetes Epidemiology and Management 5 (2022) 100037, https://doi.org/10.1016/j.deman.2021.100037.

[28] B. Bhowmik, F. Afsana, T. Siddiquee, S.B. Munir, F. Sheikh, E. Wright, et al., Comparison of the prevalence of metabolic syndrome and its association with diabetes and cardiovascular disease in the rural population of Bangladesh using the modified national cholesterol education program expert Panel adult treatment Panel III and international diabetes federation definitions, Journal of Diabetes Investigation 6 (3) (2015) 280–288, https://doi.org/10.1111/jdi.12268.

[29] S.M.B. Billah, M.S. Jahan, S. Al Jundi, A.M. Rajab, Gender differentials of metabolic syndrome in Bangladesh taking menopause into consideration, International Journal of Human and Health Sciences 5 (1) (2021) 101–107, https://doi.org/10.31344/ijhhs.v5i1.242.

[30] A. Ariadi, J. Jamsari, Y. Yanwirasti, M.F.G. Siregar, Y. Yusrawati, Correlation between estrogen levels with lipid profile in menopause women in West Sumatera, Open Access Macedonian Journal of Medical Sciences 7 (13) (2019) 2084–2087, https://doi.org/10.3889/oamjms.2019.625.

[31] R. Çırpan, A.Z. Değirmencioğlu, S.J.C.M.J. Kocaöz, Effect of the metabolic syndrome on the quality of life and sleep in women, Cukurova Medical Journal 46 (3) (2021) 1108–1116, https://doi.org/10.17826/cumj.911214.

[32] S.K. Kunti, S. Ghosh, A. Samanta, I. Chakraborty Metabolic syndrome and its socio demographic and behavioral correlates: a cross sectional study among adult patients attending medicine outpatient department in a tertiary care hospital, West Bengal, International Journal of Community Medicine and Public Health 6 (4) (2019) 1585, https://doi.org/10.18203/2394-6040.ijcmph20191388.

[33] D.E. Bloom, S. Chatterji, P. Kowal, P. Lloyd-Sherlock, M. McKee, B. Rechel, et al., Macroeconomic implications of population ageing and selected policy responses, Lancet 385 (9968) (2015) 649–657, https://doi.org/10.1016/S0140-6736(14)61464-1.

[34] K.L. Koivu, E.K. Damman, Qualitative variations: the sources of divergent qualitative methodological approaches, Qual. Quantity 49 (6) (2015) 2617–2632, https://doi.org/10.1007/s11135-014-0131-7.

[35] K.H. Lee, H. Xu, B. Wu, Gender differences in quality of life among community-dwelling older adults in low- and middle-income countries: results from the Study on global AGEing and adult health (SAGE), BMC Publ. Health 20 (1) (2020) 114, https://doi.org/10.1186/s12889-020-8212-0.

[36] X. Huang, M. Zhang, J. Fang, Q. Zeng, J. Wang, J. Li Classifying and characterizing the development of self-reported overall quality of life among the Chinese elderly: a twelve-year longitudinal study, BMC Publ. Health 22 (1) (2022) 1139, https://doi.org/10.1186/s12889-022-13314-6.

[37] C. Ee, J. Lake, J. Firth, F. Hargraves, M. de Manincor, T. Meade, et al., An integrative collaborative care model for people with mental illness and physical comorbidities, Int. J. Ment. Health Syst. 14 (1) (2020), https://doi.org/10.1186/s13033-020-00410-6, 2083.

[38] C. Wellness. Holistic Wellness: Integrating Physical, Emotional, and Mental Health [cited 2024 16/07/2024]. Available from: https://www.corporatewellnesscertification.com/?utm_campaign=New-2022-CCWS&utm_medium=Top-Bar&utm_source=CWM.

[39] WHO. Achieving well-being: a global framework for integrating well-being into public health utilizing a health promotion approach [cited 2024 16/07/2024]. Available from: https://www.who.int/publications/i/item/9789240084858.

[40] S. Kunvik, J.-C. Kanninen, A. Holm, M.H. Suominen, H. Kautiainen, J. Puustinen, Nutritional status and health-related quality of life among home-dwelling older adults aged 75 years: the PORI75 study, Nutrients 16 (11) (2024) 1713, https://doi.org/10.3390/nu16111713.

[41] K.S. Salminen, M.H. Suominen, H. Soini, H. Kautiainen, N. Savikko, R.K.T. Saarela, et al., Associations between nutritional status and health-related quality of life among long-term care residents in Helsinki, J. Nutr. Health Aging 23 (5) (2019) 474–478, https://doi.org/10.1007/s12603-019-1182-1.

[42] S. Srivastava, N. Purkayastha, H. Chaurasia, T. Muhammad Socioeconomic inequality in psychological distress among older adults in India: a decomposition analysis, BMC Psychiatr. 21 (1) (2021) 179, https://doi.org/10.1186/s12888-021-03192-4.

[43] P. Singh, D. Govil, V. Kumar, J. Kumar Cognitive impairment and quality of life among elderly in India, Applied Research in Quality of Life 12 (4) (2017) 963–979, https://doi.org/10.1007/s11482-016-9499-y.

[44] C. Yang, P. Liu, W. Huang, Y. Zhou, C. Liu, T. Gao, et al., Relationship between three dietary indices and health-related quality of life among rural elderly in China: a cross-sectional study, Front. Nutr. 10 (2023), https://doi.org/10.3389/fnut.2023.1259227.

[45] K. Norman, U. Haß, M. Pirlich, Malnutrition in older adults—recent advances and remaining challenges, Nutrients 13 (8) (2021), https://doi.org/10.3390/nu13082764.

[46] N. Acar Tek, M. Ş, Karaçil-Ermumcu Determinants of health related quality of life in home dwelling elderly population: appetite and nutritional Status, J. Nutr. Health Aging 22 (8) (2018) 996–1002, https://doi.org/10.1007/s12603-018-1066-9.

[47] T.T. Su, M. Azzani, A.P. Adewale, N. Thangiah, R. Zainol, H. Majid, Physical activity and health-related quality of life among low-income adults in metropolitan Kuala Lumpur, J. Epidemiol. 29 (2) (2019) 43–49, https://doi.org/10.2188/jea.JE20170183.

[48] H. Halaweh, C. Willen, A. Grimby-Ekman, U. Svantesson, Physical activity and health-related quality of life among community dwelling elderly, J. Clin. Med. Res. 7 (11) (2015) 845–852, https://doi.org/10.14740/jocmr2307w.

[49] W. Kamal, G. Nambi, Relationship between physical activity and health-related quality of life in elderly people: a cross section study, Sanamed 12 (2) (2017) 87–92, https://doi.org/10.24125/sanamed.v12i2.186.

[50] C.-C. Liu, H.-T. Chang, S.-C. Chiang, H.-S. Chen, M.-H. Lin, T.-J. Chen, et al., Sex differences in relationships between metabolic syndrome components and factors associated with health-related quality of life in middle-aged adults living in the community: a cross-sectional study in Taiwan, Health Qual. Life Outcome 16 (2018) 1–10, https://doi.org/10.1186/s12955-018-0910-2.

[51] F. Rashvand, A. Ghorbani, N. Esmailzadehha, Health-related quality of life in adults with metabolic syndrome: qazvin metabolic disease study, Iran, Asian Journal of Social Health and Behavior 4 (2) (2021) 69–73, https://doi.org/10.4103/shb.shb_72_20.

[52] K. Ethun, Sex and gender differences in body composition, lipid metabolism, and glucose regulation, in: G.N. Neigh, M.M. Mitzelfelt (Eds.), Sex Differences in Physiology, Academic Press, Boston, 2016, pp. 145–165.

[53] F. Mauvais-Jarvis, Gender differences in glucose homeostasis and diabetes, Physiol. Behav. 187 (2018) 20–23, https://doi.org/10.1016/j.physbeh.2017.08.016.