Case Report

Impact of obesity on quality of life: Case of the Rabat-Salé-Kénitra Region, Morocco

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ABSTRACT

Aims

This study aims to investigate the impact of obesity on quality of life, focusing on physical activity limitations among adults in the Rabat-Salé-Kénitra region of Morocco.

Materials and Methods

A cross-sectional study was conducted between January 2021 and August 2022, involving a random sample of 134 individuals aged 18 to 59 years. Inclusion criteria excluded chronic conditions likely to affect weight or physical activity. Data were collected using sociodemographic an anthropometric questionnaires, alongside the MOS SF-36 scale to assess health-related quality of life. Statistical analyses, including chi-square tests and Z-scores, were used to evaluate associations between key variables.

Results and Discussion

The sample predominantly consisted of women (62.7%), with a mean age of 39.34 ± 1.08 years. Over 72% of participants were classified as overweight or obese, and 17.6% experienced severe physical activity limitations. Significant associations were observed between physical activity limitations and factors such as BMI, urban residence, and educational level. The study also highlighted a high prevalence of comorbidities, including diabetes, orthopedic conditions, and psychiatric disorders, further emphasizing the detrimental impact of excess weight on quality of life. These findings align with global research while underscoring regional specificities.

Conclusion

Obesity significantly impairs quality of life through its impact on physical activity limitations and associated comorbidities. These results highlight the urgent need for public health interventions promoting physical activity and addressing the socio-economic and cultural determinants of obesity.

Keywords

obesity; overweight; quality of life; MOS SF-36; BMI

INTRODUCTION

Obesity and overweight are experiencing an alarming progression globally, to the extent that the World Health Organization (WHO) designated the situation as an epidemic as early as 2003[1]. This trend is attributed to socio-economic development, evolving dietary habits, and an increased consumption of calorie-dense

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foods, coupled with increasingly sedentary lifestyles. In Africa, these factors are exacerbated by sociocultural beliefs that often view excess weight as a symbol of beauty, wealth, or even good health[2].

Scientifically, obesity is defined by a body mass index (BMI) equal to or greater than 30 kg/m² [3]. It is a complex condition resulting from an energy imbalance, which induces chronic inflammation and predisposes individuals to numerous severe conditions, including metabolic syndrome, hypertension, cardiovascular and renal diseases, type 2 diabetes, certain cancers, and sleep apnea [4]. Furthermore, obesity is associated with increased vulnerability to respiratory infections, such as seasonal influenza and COVID-19, often exacerbating their complications[1].

These chronic comorbidities lead to a significant deterioration in quality of life and considerably heighten the risk of severe complications, including premature death[5]. Additionally, obese individuals are frequently subjected to prejudice and weight-based discrimination, further exacerbating negative psychological effects independent of underlying medical issues[6]. In Bangladesh, as in many other developing countries, the rising prevalence of obesity among children and adolescents highlights a major public health challenge, particularly linked to modern urban lifestyles[7]. A study conducted among schoolchildren aged 6 to 12 years in Bangladesh revealed that 17.6% were overweight and 21.8% obese in urban areas, whereas these rates were 2.6% and 1.5%, respectively, in rural areas[8].

At a societal level, obesity constitutes a significant burden on healthcare systems, both in terms of economic costs and social implications[4]. In light of this pressing public health concern, it is crucial to better understand the impacts of obesity on quality of life to design effective and tailored interventions. The present study thus aims to explore the effects of obesity on quality of life, focusing on functional limitations in performing daily physical activities.

MATERIALS AND METHODS

Study Site and Population

This study was conducted in the Rabat-Salé-Kénitra region (Morocco) between January 2021 and August 2023. The sample consisted of 134 participants of both sexes, aged between 18 and 59 years. Participants were selected through horizontal simple random sampling (SRS). Inclusion criteria required individuals to be free of chronic conditions influencing body weight or limiting physical activity, such as cardiac disorders, thyroid dysfunctions (hypo- or hyperthyroidism), or severe mobility impairments.

Sampling Methods and Data Collection Tools

Participants were informed about the study's objectives, and written informed consent was obtained prior to their inclusion. Data were collected using a structured questionnaire consisting of:

- A first section collecting sociodemographic and anthropometric information.
- A second section based on the validated MOS SF-36 (Medical Outcomes Study 36-Item Short Form Health Survey), designed to assess health-related quality of life.

Anthropometric Measurements

The weight and height of participants were measured with a precision of 0.1 kg and 0.1 cm, respectively, using calibrated instruments: a portable scale (Seca Gmbh & Co., Germany) and a Shorr portable board (Shorr Productions, USA). The body mass index (BMI) was calculated using the following formula: BMI=Weight (kg)Height (m)2\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}BMI=Height (m)2Weight (kg) Participants were categorized into six groups according to the WHO classification:

- < 18.5: Underweight
- 18.5–24.9: Normal weight
- 25.0–29.9: Overweight
- 30.0–34.9: Obesity Class I
- 35.0–39.9: Obesity Class II
- ≥ 40: Obesity Class III (severe obesity)

Quality of Life Assessment

Participants' quality of life was evaluated using the MOS SF-36, a recognized tool for measuring various aspects of physical and mental health. This instrument is widely employed in clinical research and has been validated across diverse populations.

Ethical Approval and Compliance

The study was conducted in compliance with the ethical standards outlined in the Declaration of Helsinki (1964) and its amendments (2000). Ethical approval was

obtained from the Ethics Committee of Mohammed V University in Rabat (Reference: CE-UMVR/21/01). All participants provided written informed consent before their participation. The authors declare that no conflict of interest is associated with this research.

Data Analysis

Data were entered into an Excel spreadsheet and, after filtration, transferred to an SPSS sheet for statistical analysis. Qualitative variables were expressed as frequencies, while quantitative variables were presented as means ± standard deviation. The chi-square independence test and analysis of variance (ANOVA) were applied with a significance level set at 5%. Scores were transformed into Z-scores with the following thresholds: $Z < -1$ (severe limitation); $-1 \leq Z \leq 1$ (moderate limitation); $Z > 1$ (no limitation). The biological indicators used included the following: TME (disease rate among individuals exposed to obesity), TMNE (disease rate among non-exposed individuals), PREV (prevalence), RA (attributable risk), ODDS (odds ratio), and CI (95% confidence interval for odds ratio).

RESULTS

Socio-Demographic Characteristics:

Table 1 presents the results regarding the socio-demographic characteristics of the respondents based on their gender. Notably, female respondents constitute a substantial majority, representing 62.7% of the total participants, while male respondents account for the remaining 37.3%. This translates to a female-to-male ratio of 1.68:1.

Additionally, an analysis of age distribution reveals that the mean age of the respondents is 39.34 ± 1.08 years. Interestingly, the most common age group in the sample comprises individuals under 40 years old, representing 50.74% of the total participants.

Furthermore, a chi-square analysis indicates a statistically significant association between economic level and gender ($\chi^2 = 10.73$; $p < 0.03$). Among the participants who reported a financial income not exceeding 1000 MAD (n = 40), 82.5% were women. This observation highlights a notable gender disparity in financial resources among the respondents.

Regarding the place of residence, a significant majority of participants, 65.12%, live in urban areas. Moreover, an analysis of participants' educational qualifications shows that 70% have a level of education not exceeding secondary school. This finding underscores the predominance of individuals with limited formal education within the study sample.

Anthropometric Characteristics:

The anthropometric characteristics of the population are detailed in Table 2. The distribution of participants

Table 1: Socio-Demographic Characteristics of Respondents:

Variable	Category	Female (62.7%; n=84)	Male (37.3%; n=50)	Total	Chi-square (p-value)
Place of residence	Rural	31	14	45	1.38 (p < 0.24)
	Urban	49	35	84	
Educational level	Basic	33	14	47	2.42 (p < 0.30)
	Secondary	24	20	44	
	Higher education	25	14	39	
Economic level	< 1000 MAD	33	7	40	10.73 (p < 0.03)*
	1000–3000 MAD	27	21	48	
	3000–5000 MAD	6	5	11	
	5000–10,000 MAD	3	1	4	
	> 10,000 MAD	14	15	29	
Age group	< 40 years	46	22	68	1.75 (p < 0.62)
	40–50 years	22	16	38	
	50–60 years	12	10	22	
	> 60 years	4	2	6	

based on their weight and height indicates an average weight of 80.87 ± 1.37 kg, with a minimum of 49 kg and a maximum of 117 kg. The average height was 167.59 ± 0.59 cm, ranging from 153 cm to 187 cm. Fisher's test revealed a statistically significant difference in both average weight and height between genders, with values of F = 14.56 (P < 0.000) and F = 60.74 (P < 0.000), respectively.

Regarding BMI, 27.61% of participants were classified as having normal weight, 25.37% as overweight, and 47.01% (n = 63) as obese. Among the obese group, 79.36% were categorized as Class I obese, while 19.04% were categorized as Class II obese. It is worth noting that only one female participant was classified as severely obese. Chi-square analysis did not demonstrate a significant association between gender and BMI (χ^2 = 1.27; p < 0.53).

Table 2: Distribution of Participants by BMI and Gender

Variable	Category	%	Female	Male	Total
BMI	Normal weight	27.61% (n=37)	26	11	37
	Overweight	25.37% (n=34)	20	14	34
	Obesity Class I	47.01% (n=63)	32	18	50
	Obesity Class II	8.96% (n=12)	5	7	12
	Severe obesity	0.75% (n=1)	1	0	1
Total			84	50	134

Clinical Characteristics and Medical History

Figure 1 illustrates the distribution of participants by gender and medical history. A significant proportion of the population, 16.4%, is affected by diabetes, while 14.2% suffer from hypertension (HTA). Notably, the majority of individuals with these conditions are women, with 14 cases compared to only 5 among men.

Furthermore, 13.40% of participants reported orthopedic disorders, and 12.70% suffered from psychiatric conditions. Strikingly, most individuals with psychiatric disorders were women (n = 12).

Additionally, the presence of patients with other conditions, such as cardiac, renal, and urinary diseases, underscores the broad range of medical issues monitored in the study.

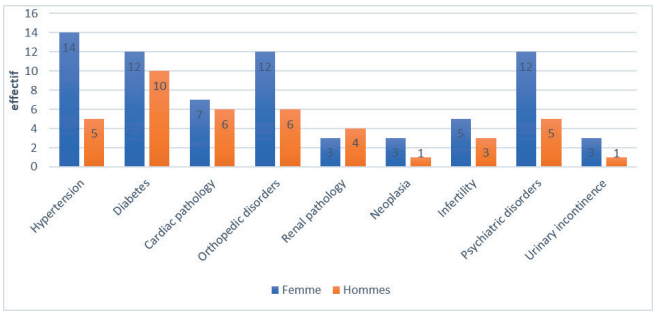

Figure 1: Distribution of Participants by Gender and Medical History

Combined Analysis of BMI and Medical History:

Table 3 presents the cross-analysis results between BMI and the reported medical history of participants. Hypertension (HTN) prevalence among overweight or obese individuals is 16.49%, significantly higher than the 8.11% observed in individuals with normal weight. The attributable risk for HTN in overweight or obese individuals is 8.38%. Additionally, the odds ratio (OR) for HTN in this group is 2.24, with a confidence interval (CI) ranging from 0.61 to 8.21.

In contrast, diabetes prevalence among obese individuals is remarkably high at 22.68%, while it is nearly nonexistent in participants without obesity. The attributable risk for diabetes in obese individuals is 22.6%.

Focusing on cardiac pathology, the rate of disease among overweight or obese individuals is 10.31%, with an OR of 0.92 and a CI of 0.23–3.61. Similarly, orthopedic complications are significantly more prevalent in overweight or obese participants (16.49%) compared to those with normal weight (5.41%). The OR for orthopedic issues in this group is 3.46, with a CI of 0.75–15.8.

Renal pathology affects 8.11% of obese individuals, compared to 4.12% of normal-weight participants, with a CI of 0.1–2.3. Additionally, the prevalence rates of neoplasia, infertility, and urinary disorders in overweight or obese individuals are 4.12%, 8.25%, and 4.12%, respectively, while these conditions are absent in normal-weight individuals.

Finally, psychiatric conditions are significantly more frequent among overweight or obese individuals (15.24%) compared to those with normal weight (2.63%). The attributable risk for psychiatric conditions in this population is 12.6%, with an OR of 6.65 and a CI of 0.85–51.99.

Table 3: Biological Indicators Between BMI Categories and Medical History

Medical history	BMI		Total	Chi2 (*p*-value)	TME	TMNE	PREV	RA	ODDS	CI
	Normal	Overweight or obese								
Hypertension	3	16	19	2,51 (p<0,28)	16,49	8,11	14,1	8,38	2,24	0,61-8,21
Diabetes	0	22	22	10,21 (p<0,006)**	22,68	0	16,4	22,6	non	non
Cardiac pathology	3	10	13	1,3 (p<0,51)	10,31	11,11	10,4	(-0,8	0,92	0,23-3,61
Orthopedic Issue	2	16	18	3,84 (p<0,05)*	16,49	5,41	13,4	11,0	3,46	0,75-15,8
Renal Pathology	3	4	7	3,19 (p<0,2)	4,12	8,11	5,22	-3,99	0,49	0,1-2,3
Neoplasia	0	4	4	4,65 (p<0,046)*	4,12	0	2,99	4,12	non	non
Infertility	0	8	8	9,59 (p<0,008)**	8,25	0	5,95	8,25	non	non
Psychiatric Issues	1	16	17	17,46 (p<0,000)***	15,24	2,63	11,8	12,6	6,65	0,85-51,99
Urinary Disorders	0	4	4	4,65 (p<0,046)*	4,12	0	2,99	4,12	non	non

Study on Quality of Life Assessment (MOS SF-36):

The assessment of the quality of life using the MOS SF-36 scale demonstrated strong internal consistency reliability, as indicated by a Cronbach's alpha coefficient of 0.918, confirming the validity of the instrument (Fisher = 62.56; $p < 0.000$). Notably, the deletion of any single item resulted in a decrease in the Cronbach's alpha value, further emphasizing the critical importance of each component within the scale.

To categorize participants based on activity limitations, scores were aggregated. The mean score was calculated to be 24.8 ± 0.41 points, with observed values ranging from a minimum of 10 to a maximum of 30 points. The distribution of scores, expressed in terms of corresponding Z-scores, revealed that 17.6% of respondents experienced severe limitations in their daily activities, significantly impacting their quality of life. An equal proportion of participants reported no limitations, while the majority (64.8%) exhibited moderate limitations.

The latter group, representing the majority, requires close monitoring to prevent the progression of moderate limitations into severe restrictions. This highlights the necessity for targeted interventions aimed at improving the functional capacity and overall quality of life of affected individuals. (Refer to Figure 2 for a graphical representation of the Z-score distribution.)

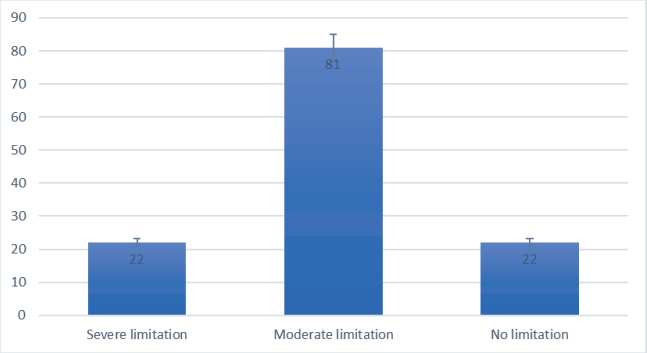

Figure 2: Distribution of Participants Based on Z-Score

Chi-Square Test Between Categories and Specific Factors:

In this section, we conducted a chi-square test of independence to examine the relationship between activity limitations associated with pathological BMI and certain sociodemographic variables. The variables *Place of Residence*, *Educational Level*, and *BMI* exhibited statistically significant associations, with p-values below 0.044, 0.004, and 0.05, respectively. Specifically, a significant association emerged between BMI and activity limitations. Among overweight or obese individuals, 19.78% demonstrated severe limitations in daily activities, compared to 11.76% of individuals with normal weight.

Obesity can result in various activity limitations due to its impact on physical, mental, and emotional health. These limitations include mobility difficulties, shortness of breath, fatigue, pain, increased risk of injuries, sleep problems, and psychosocial impacts.

Regarding the link between place of residence and activity limitation, it was observed that 19.48% of participants from urban areas experienced severe physical activity limitations, compared to 11.63% from rural areas. Moreover, 32.56% of respondents with a low educational level suffered from severe physical limitations, compared to only 1.01% of individuals with education at the high school level or higher.

DISCUSSION

The present study focuses on assessing the quality of life, particularly the physical activity component, among overweight and obese individuals. The research involved 134 participants, over 62% of whom were women, with an average age of 39.34 ± 1.08 years. Approximately 65.12% of respondents resided in urban areas. Regarding Body Mass Index (BMI), more than 72% of the participants were classified as overweight or obese. These findings align with prior studies conducted in Morocco, which highlight a concerning increase in the prevalence of overweight and obesity. Indeed, surveys conducted in Morocco over the past decades have demonstrated a significant upward trend in these indicators. A study conducted in 2014 by the University of Mohammed V in Rabat reported an obesity prevalence of 20.2% and a prevalence of 42.8% for overweight individuals. A more recent survey, carried out in 2016 by the National Institute of Nutrition[9], revealed that obesity prevalence among adults was 19.9%, while the prevalence of overweight reached 43.9%. On an international scale, the results obtained are consistent with global trends. The prevalence of obesity has nearly tripled between 1975 and 2016. According to data from the World Health Organization (WHO), in 2016, more than 1.9 billion adults (39% of the global population) were overweight, with over 650 million (13%) classified as obese. In 2022, the WHO warned of a "predictable and preventable health crisis"

Table 4: Chi-Square Test Between Activity Limitations and the Variables Listed Below

Variable	Category	Quality of life category			Total	Chi2
		Severe limitation	Moderate limitation	No limitation		
residence	Rural	5	26	12	43	4,58 (p<0,044)*
	Urban	15	52	10	77	
Total		20	78	22	120	
Education level	Primary	14	24	5	43	13,27 (p<0,004)**
	Secondary	4	34	6	44	
	Higher	4	21	10	35	
Total		22	79	21	122	
BMI	normal	4	21	9	34	3,06 (p<0,05)*
	Overweight or obese	18	60	13	91	
Total		22	81	22	125	

linked to the continuous rise in obesity, with one billion obese individuals recorded worldwide.

Similar trends have been reported in several countries. A study published in the *Bangladesh Journal of Medical Science* highlighted that the prevalence of obesity is particularly concerning, reaching 21.8% among children in urban areas[8]. In France, the proportion of overweight or obese individuals increased by 42% between 1997 and 2006 [10]. In Canada, the prevalence of obesity and overweight has tripled since 1985. Severe obesity, in particular, has quadrupled, affecting approximately 1.9 million Canadians in 2016 [11]. Similarly, in Tunisia, the prevalence of obesity has more than doubled over the past two decades, reaching 22.7% [12] .

The combined study of BMI and medical history revealed that most participants exhibited at least one of the medical conditions analyzed**.** Overweight or obese individuals were found to suffer from associated diseases, including hypertension (16.49%), diabetes (22.68%), musculoskeletal disorders (16.49%), and psychological conditions (15.24%). The impact of hypertension and its association with obesity has been extensively documented in collaborative analyses of 57 prospective studies investigating the relationship between Body Mass Index (BMI) and cause-specific mortality in 900,000 adults. These studies demonstrated a positive and nearly linear correlation between BMI and systolic and diastolic blood pressure, such that each 5 kg/m² increase in BMI was associated with a rise of at least 5 mm Hg in systolic blood pressure[13]. Another notable finding from this study was the statistically significant relationship between obesity and type 2 diabetes. This association is supported by recent studies indicating that obesity increases the risk of developing type 2 diabetes tenfold. Approximately three-quarters of individuals with type 2 diabetes are obese, a phenomenon attributed to the combined effects of muscle and hepatic insulin resistance, along with reduced insulin secretion by pancreatic β-cells[14]. Additionally, a cohort study conducted in the United States on healthcare professionals monitored 27,200 participants over 13 years, revealing that 884 individuals developed type 2 diabetes. This figure is significantly higher than that observed in the general population, and the relative risk of developing diabetes increased progressively with higher BMI quintiles, confirming a dose-dependent relationship between excess weight and diabetes[15]. Furthermore, a recent global study underscored that obesity is the primary modifiable factor in the prevention of type 2 diabetes due to its critical role in insulin resistance[16]. Musculoskeletal complications represent a significant concern among obesity-related comorbidities**,** with direct consequences on patients' quality of life. These complications are primarily linked to increased mechanical stress on weight-bearing joints, such as the knees, hips, and lumbar spine. Such excessive pressure not only causes cartilage damage but also promotes physical inactivity, creating a vicious cycle of worsening obesity. Our findings align with those reported in the scientific literature, emphasizing the vulnerability of knee joints in obese patients due to repeated stress[17]. Complementing this, a cohort study in the United Kingdom involving 490,532 women aged 50–69 years, followed over five years, identified a proportional relationship between BMI and the likelihood of undergoing hip or knee arthroplasty. The study found that increased BMI significantly heightened the probability of requiring these surgical interventions[18]. Recent research published in the *Bangladesh Journal of Medical Science* further highlights this issue. Rahman et al. (2022) demonstrated that obesity substantially raises the risk of developing musculoskeletal disorders, particularly osteoarthritis of the knees and hips, significantly impairing patient mobility. These conditions are exacerbated by the reduced physical capacities often associated with obesity, as also noted by Rashid and Haque (2022). These authors emphasize the importance of breaking this cycle through early and tailored therapeutic interventions.

Another significant aspect to highlight is the relationship between psychological disorders and overweight or obesity. Studies have shown that 20% to 70% of individuals with severe obesity experience psychiatric disorders, with depression being the most common. A study published in the *Journal of Psychosomatic Research* examined the psychological backgrounds of obese individuals and found significantly higher rates of depression and anxiety among obese individuals compared to those without obesity[20]. Additionally, a systematic review published in *Obesity Reviews* revealed that obese individuals are more likely to suffer from mood disorders, particularly depression, emphasizing the psychological impact of obesity on quality of life[21]. However, it is important to note that these studies do not establish a direct causal relationship between psychological disorders and obesity but rather suggest a significant association between these factors.

Other elements, such as genetics, socioeconomic environment, and dietary habits, also play a role in the development of obesity.

Regarding the place of residence, several studies have clearly demonstrated disparities in obesity prevalence between urban and rural areas. Interestingly, obesity can often be explained by physical activity limitations, as confirmed by our study, particularly in urban settings and among individuals with middle or high school education levels. Similarly, a study published in 2013 in *Public Health Nutrition* reported a higher prevalence of obesity in urban areas (21.9%) compared to rural areas (14.1%) [22]. Another study, published in 2016 in *BMC Public Health*, revealed similar prevalence rates, with 25.6% obesity in urban settings compared to 15.9% in rural ones [23]. Additionally, in France, a survey indicated that adults living in rural areas were more likely to engage in regular physical activity than those living in urban areas[23]. More recently, a study conducted by Rashid and Haque (2022) highlighted a significantly higher prevalence of obesity in urban zones, linked to more sedentary behaviors and imbalanced dietary habits compared to rural areas, where physical activity levels are generally higher. Another study, published in the *Bangladesh Journal of Medical Science* by Islam et al. (2024), explored obesity differences among children aged 6 to 12 years. The findings revealed that 21.8% of children living in urban areas were obese, compared to only 1.5% in rural areas. These results underline the critical role of urban lifestyles, characterized by reduced physical activity and increased consumption of processed foods.

From an educational perspective, several studies have highlighted a significant relationship between adults' educational level and their participation in physical activities. Generally, individuals with a higher level of education are more likely to adopt behaviors that promote regular physical activity compared to those with lower education levels. A recent study conducted in the United States revealed that university graduates were significantly more likely to engage in regular physical activities, possibly due to increased awareness of the benefits of exercise and better access to sports facilities[24]. Similar findings in Australia also confirm that individuals with higher educational attainment are more involved in sports activities. These studies emphasize that education not only influences the frequency of physical activities but also their nature, with more educated individuals often opting for recreational activities rather than professional ones[25]. Furthermore, a European study revealed that the correlation between educational level and physical activity varies across cultural and economic contexts. For instance, populations with lower educational levels in certain countries are less likely to be physically active due to socio-economic barriers, such as a lack of appropriate infrastructure or insufficient time due to demanding jobs[26]. These findings call for educational policies that incorporate the promotion of physical activity from an early age to reduce health inequalities

In summary, being overweight can have a significant impact on quality of life. Obesity can affect numerous aspects of daily living, such as physical health, mental well-being, social relationships, mobility, and self-confidence. In turn, these effects can influence an individual's overall quality of life.

Physically, obesity is associated with an increased risk of developing health issues such as type 2 diabetes, cardiovascular diseases, hypertension, joint disorders, respiratory problems, and certain cancers (World Health Organization, 2021; Rahman et al., 2022). These health problems can limit an individual's ability to perform daily activities and enjoy life, further exacerbating the cycle of being overweight.

Mentally and emotionally, obesity can lead to low self-esteem, depression, anxiety, and body image issues. Obese individuals may also experience social stigma and discrimination, which can negatively impact their emotional well-being and social relationships. Furthermore, mobility can be affected by obesity, limiting participation in physical, social, and professional activities. This can lead to social isolation and a decline in quality of life.

CONCLUSION

In conclusion, it is crucial to recognize that the relationship between obesity and quality of life is complex and multifaceted. Weight loss and adherence to healthy lifestyle habits can improve the quality of life for obese individuals. However, it is essential to adopt a comprehensive and holistic approach that takes into account the physical, mental, and social aspects of quality of life.

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Conflict of Interest

The authors assert that there are no conflicts of interest associated with this research.

Ethical clearence

There was no need for ethical clearance for this research.

Authorship contribution:

Hasna Kachache: Acquisition of data, data analysis, interpretation of results, writing-original draft and submitting manuscript, Sara Ait Lachguer, Meryem Bouhamida, Nihal Abitiu: involved in writing, reviewing, Fadia Bejja: reviewing, Amina Bouziani, Hasnae Benkirane: supervision and writing-review, Hasna Kachache, Chahboune Mohammed, Hasnae Benkirane: interpretation of results, writing-original draft, reviewing and editing. All authors have read and agreed on the final version of the manuscript.

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