The association of Body Mass Index with Quality of Life and Working Ability: a Finnish population-based study

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Abstract

Purpose

The impact of obesity on quality of life (QoL) and working ability vary in different dimensions. This study investigated the association of obesity with QoL and working ability in Finnish adults. Comorbidities as associative factors were also characterised.

Methods

The study included 4,956 randomly selected adults. QoL (EUROHIS-QOL 8 total score and individual components), perceived physical and psychological working ability, and sick leave days were analysed in different BMI groups. Regression models were used to study the role of comorbidities as associative factors.

Results

EUROHIS-QOL 8 total score was significantly lower in BMI group 25.0–29.9 kg/m^2 (4.01; 95% confidence interval 3.97–4.05), BMI 30.0–34.9 kg/m^2 (3.85; 3.79–3.91), BMI 35.0–39.9 kg/m^2 (3.75; 3.66–3.85), and BMI ≥40.0 kg/m^2 (3.73; 3.46–4.00) compared to individuals with normal (18.5–24.9 kg/m^2) BMI (4.08; 4.04–4.12). Individuals with obesity (BMI ≥30.0 kg/m^2) rated their QoL lower than individuals with normal BMI in seven of the eight EUROHIS-QOL 8 components. A lesser proportion of individuals (53–73%) with obesity rated their physical working ability as very or fairly good compared to individuals with normal BMI (90%, p-values <0.001). The psychological working ability was rated as very or fairly good by 71–75% of individuals with obesity compared to 85% of individuals with normal BMI (p=0.008 and p=0.001 in individuals with BMI 30.0–34.9 and BMI 35.0–39.9 kg/m^2, respectively).

Conclusions

Obesity was negatively associated with both physical and psychological components of QoL, even after accounting for obesity-related comorbidities. Obesity treatment can benefit from a holistic approach that considers these multifaceted associations.

Keywords

Body mass index, Obesity, Quality of Life, Working ability

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Introduction

The increasing prevalence of overweight and obesity is a global public health concern. In 2016, over 1.9 billion adults worldwide were overweight (body mass index, BMI ≥25.0 kg/m^2), and of these over 650 million had a BMI ≥30.0 kg/m^2 (obesity) [1]. Obesity is a major risk factor for a number of chronic diseases, reduces life expectancy, and is associated with the loss of potential disease-free years in middle and late adulthood [2,3].

In addition to presenting a significant risk for individual´s physical health, obesity has negative implications for psychological health, social well-being, and functional ability [4,5]. Obesity is associated with reduced quality of life (QoL) even in the absence of complications [6–8].

Previous studies have shown a consistent negative impact on functional ability and general health, whereas the relationship between psychological domains of QoL and obesity seems to be more complex [8–10]. Stigma and discrimination toward individuals with obesity increase the risk for psychosocial problems, and individuals with obesity are more likely to suffer from various mood disorders and depression than those with normal BMI [11–13]. Together, these factors may cause challenges in working life, resulting in lower work productivity, increased risk of work absence, and disability pensions [14].

Factors mediating the deteriorating effect on QoL and working ability are not well characterised, and the role of obesity as an independent factor (without related comorbidity) is not fully understood. It has been shown that poor QoL is also a risk factor for weight gain, and the association between obesity and QoL is potentially confounded by many biological and sociodemographic factors [10,15,16]. Diabetes, metabolic syndrome, heart disease, osteoarthritis, and high blood pressure have been suggested as potential mediators between BMI and QoL, and the presence of comorbidities has been reported to be associated with a decrease in QoL in individuals with obesity [7,17,18].

Population-based health examinations surveys, with random representative samples, provide an excellent basis to study the effects of BMI on QoL without the bias associated with clinical trials or other interventional studies. The FinHealth 2017 study indicated that obesity is becoming increasingly prevalent in Finland [19]. However, the association of obesity with QoL or functional ability has not been assessed in the general Finnish adult population. The aim of this study was to examine the association between BMI group and QoL in the general adult population of Finland

using EUROHIS-QOL 8 measure covering psychological, physical, social, and environmental domains of QoL [20]. In addition, we studied perceived psychological and physical working ability, and self-reported sick leaves in different BMI groups. A multivariable model adjusted for obesity-related comorbidities was used to characterise the potential associative factors between BMI group and QoL as well as BMI group and working ability.

Methods

Study cohort

This study was based on cross-sectional data collected in the FinHealth 2017 study, conducted by the Finnish Institute for Health and Welfare [19], to produce information on health, health behavior, functional capacity and well-being of adults in Finland. In the FinHealth 2017 study, 10,000 adults (≥18 years of age) were sampled from mainland Finland, using a stratified one- and two-stage design [21]. The data were gathered using health examination measurements and self-administered questionnaires. Of the recruited individuals, 71% participated at least in one part of the examinations or questionnaires, and 60% participated in the health examination.

A population flowchart for this study is presented in Annex Fig. 1 (see Supplementary Materials 1). The analyses are based on those 5,587 FinHealth 2017 study participants who had measured BMI available and who were not underweight (BMI <18.5). Separate sub-cohorts were employed as relevant for each of the analyses. Specifically, The QoL analyses were restricted to those who had at least seven of the potential eight EUROHIS-QOL 8 components available (n=4,956). The working ability analyses were further restricted to those in the working age (20–64 years, n=3,263), and work absence analyses to those who were also employed or self-employed (n=2,411). A subgroup analysis

of the association of EUROHIS-QOL 8 total score with BMI was performed separately in individuals with and without any comorbidities.

Outcome measures and explanatory variables

Analysed variables are based on the FinHealth 2017 health examination measurements (BMI), or self-administered questionnaires (all other variables). The primary objective of the study was to assess QoL in different BMI groups. QoL was evaluated using the EUROHIS-QOL 8 index, which is a shortened version of original WHOQOL-BREF and has eight components covering mental, physical, social, and environmental domains of QoL (two components of each domain) [20]. Each of the components has five answer options: “very dissatisfied” (1), “dissatisfied” (2), “neither satisfied nor dissatisfied” (3), “satisfied” (4), “very satisfied” (5). The EUROHIS-QOL index has 8 items, each of which provided a score from 1 to 5 for the calculation of the sum of components. The EUROHIS-QOL 8 total score was calculated as the sum of the components divided by the number of available components. The range of the EUROHIS-QOL 8 total score is thus from 1 to 5. The individual EUROHIS-QOL 8 components were also analysed as binary variables with the following two clinically meaningful levels: 1) satisfied or very satisfied vs. 2) very dissatisfied, dissatisfied, or neither satisfied nor dissatisfied. Technically, these binary variables had value 1 if the answer was 4 or 5 and 0 for all other answers.

Perceived physical and psychological abilities to work were analysed based on the question “How would you evaluate your current work ability in terms of the physical/psychological demands of your work?”. The replies were analysed as binary variables, with value 1 if the corresponding question was answered as “very good” or “fairly good”, and 0 if the answer was “average”, “fairly

poor" or "very poor". In addition, self-reported sick leave days in the past 12 months were analysed as a continuous and binary variable (value 1 for having 14 sick leave days or more, and 0 otherwise).

BMI was categorised as normal (18.5–24.9), overweight (25.0–29.9), class I obesity (30.0–34.9), class II obesity (35.0–39.9), or class III obesity (≥40.0). The following self-reported comorbidities were used in the analyses as detailed in the supplementary methods: cardiovascular disease, cancer, musculoskeletal disease, psychiatric disorder, respiratory disease, and sleep apnea. In addition, the number of comorbidities per participant (categorised as 0, 1, 2, and ≥3) was compared between BMI groups (see Supplementary Materials 3).

Statistical analyses

In all analyses, weighting of observations was used to match the distribution of known background factors (age, sex etc.) in the group of participants with that in the whole Finnish population [21]. The analysis weight was obtained as the inverse of the product of sampling and non-response probabilities, calibrated so that the sum of weights equals the population size in each sampling design stratum. Data were described as means and proportions, together with the corresponding confidence intervals. ANOVA or chi-squared test was used in descriptive comparisons. In formal analyses, linear or logistic regression was used. Three different sets of variables were used in the multivariable models: 0) a model including BMI (18.0–24.9 as the reference), age (as a continuous variable) and sex (man vs. woman); 1) a model including BMI, demographics (age and sex) and each of the comorbidities as separate variables (yes vs. no, per comorbidity); 2) a model including BMI, demographics and count of comorbidities (0 as the reference, 1, 2, and ≥3).

For the effect size analysis, Cohen´s d was determined by calculating the mean difference divided by the pooled standard deviation. The effect size can be interpretated as follows: values greater than 0.2, 0.5, and 0.8 can be considered as small, medium and large differences, respectively [22]. The effect sizes were calculated for different BMI groups using individuals with normal BMI as reference. R version 3.6.2 was used as the statistical software, with *survey* as the main statistical package.

Results

Characteristics of the study population

Based on the FinHealth 2017 study, in 2017, 43% of Finnish men had BMI 25.0–29.9 and 25% had BMI ≥30.0 (obesity) (see Annex Table 1 in Supplementary Materials 2). Correspondingly, 33% of women had BMI 25.0–29.9 and 25% had BMI ≥30.0. The mean age of individuals with either overweight or obesity was higher than that of those with normal BMI (Table 1). In addition, the level of education, employment status, marital status, and annual household income varied in different BMI groups.

The prevalence of cardiovascular and musculoskeletal diseases, respiratory diseases, cancer, and sleep apnea varied between BMI groups (all p-values <0.001, with the exception of cancer, p=0.037; and respiratory disease, p=0.001) (see Annex Table 2 in Supplementary Materials 2). The mean number of comorbidities pooled in subgroups was 0.8 in class I and II obesity and 1.0 in class III obesity, compared to 0.5 in individuals with normal BMI (p<0.001). The percentage of individuals with two or more comorbidities was 18%, 19% and 31%, in class I, II, and III obesity, respectively, compared to 8% in individuals with normal BMI.

Quality of life assessed by EUROHIS-QOL 8 total score

The mean EUROHIS-QOL 8 total score was lower in individuals with obesity (3.73–3.85 in different obesity classes) compared to individuals with normal BMI (4.08) (Fig. 1a). The EUROHIS-QOL 8 total score decreased consistently with rising BMI group in both sexes (with the exception of BMI ≥40 group in men) (see Annex Table 3 in Supplementary Materials 2). When adjusted for age and sex, the difference in the EUROHIS-QOL 8 total score was significant in all obesity classes, compared to individuals with normal BMI ($p<0.001$ in class I and II obesity, $p=0.009$ in class III obesity). The effect sizes (Cohen's d) were 0.36 for class I obesity, 0.52 for class II obesity, and 0.53 for class III obesity (see Annex Table 4 in Supplementary Materials 2).

The first multivariate linear regression model analysis adjusted for age, sex, and comorbidity subgroups showed that class I, II, and III obesity were associated with -0.194, -0.268, -0.263 lower EUROHIS-QOL 8 scores, respectively, compared to individuals with normal BMI ($p<0.001$ for class I and II obesity; $p=0.025$ for class III obesity) (Fig. 1b). Of comorbidities studied, psychiatric disorder had the strongest association with QOL, with -0.698 lower EUROHIS-QOL 8 score ($p<0.001$). Cardiovascular, musculoskeletal, and respiratory disease, and sleep apnea were also associated with significantly lower EUROHIS-QOL 8 scores (p-values <0.001, with the exception of sleep apnea, $p=0.030$). In the second multivariate linear regression model analysis adjusted for age, sex, and number of comorbidities, having one, two, or three or more comorbidities were associated with -0.242, -0.480, and -0.695 lower EUROHIS-QOL 8 total scores, respectively (all p-values <0.001).

Class I obesity was associated with -0.190 and -0.220 lower EUROHIS-QOL 8 scores in the pooled groups of individuals without comorbidity and individuals with ≥1 comorbidity, respectively (age- and sex-adjusted p<0.001) (see Annex Fig. 2 and 3 in Supplementary Materials 1). Class II obesity was associated with -0.284 and -0.314 lower EUROHIS-QOL 8 scores in individuals without comorbidity and individuals with ≥1 comorbidity, respectively (adjusted p<0.001).

Quality of life assessed by individual EUROHIS-QOL 8 components

When adjusted for age- and sex, the proportions of individuals who rated their QoL as "good or very good" differed significantly across BMI groups for seven of the eight EUROHIS-QOL 8 components (Fig. 2, Annex Table 3 in Supplementary Materials 2). In different obesity classes, 67–69% of individuals rated their overall QoL good or very good compared to 82% in individuals with normal BMI (p-values <0.001 in obesity classes I and II; p=0.007 in class III). The percentage of individuals who were satisfied with their general health was 54–66% in different obesity classes compared to 84% in individuals with normal BMI (p-values <0.001). In different obesity classes, 64–67% of individuals reported to have completely or mostly enough energy for everyday life activities, while the percentage was 80% in individuals with normal BMI (p-values <0.001 in class I and II obesity; p=0.024 in class III obesity). Individuals with obesity were also less satisfied with themselves and their ability to perform daily activities compared to individuals with normal BMI.

Differences between sexes were observed in individual EUROHIS-QOL 8 components especially in class II obesity (see Annex Table 3 in Supplementary Materials 2). In that group, women were more often satisfied with their general health (66% of women vs. 51% of men), ability to perform daily activities (84% vs. 70%), themselves (76% vs. 62%), and their personal relationships (76% vs. 68%).

In all obesity classes, a smaller proportion of women than men reported to have completely or mostly enough energy for everyday life.

Perceived physical and psychological working ability and work absence

In all obesity classes, a significantly lower proportion of individuals (53–73%) rated their current physical working ability as very good or fairly good compared to individuals with normal BMI (90%, p-values <0.001) (Fig. 3a). The psychological working ability was rated as very good or fairly good by 71–75% of individuals with obesity vs. 85% of individuals with normal BMI (p=0.008 in class I obesity and p=0.001 in class II obesity) (Fig. 3b).

The mean number of sick leave days during the past 12 months was 7.7 days in individuals with normal BMI, 11.3 days in class I obesity, 12.9 days in class II obesity, and 7.6 days in class III obesity (Fig. 3c). When adjusted for age and sex, the difference was significant in class I (p=0.012) and II (p=0.072) obesity compared to individuals with normal BMI. The proportion of individuals who had more than 14 sick leave days was significantly higher in class I (19%) and II (22%) obesity compared to individuals with normal BMI (10%, adjusted p-values <0.001) (Fig. 3d).

In the multivariate logistic regression model analysis adjusted for age, sex, BMI group, and comorbidity subgroups, higher BMI was negatively associated with good physical working ability in all obesity classes (all p-values <0.001) (see Annex Fig. 4 in Supplementary Materials 1). The odds for good psychological working ability was significantly lower in obesity class I (p=0.030) and II (p=0.017) (see Annex Fig. 5 in Supplementary Materials 1). Comorbidity subgroups significantly negatively associated with good physical and psychological working ability were cardiovascular,

musculoskeletal, and respiratory diseases, and psychiatric disorder. Sleep apnea was associated with lower psychological, but not physical, working ability. Having three or more comorbidities was most strongly negatively associated with good working ability: the ORs were 0.091 and 0.090 for physical and psychological working ability, respectively ($p<0.001$).

Discussion

This is the first study to investigate the association between BMI and QoL and working ability in the general population of Finland. Results indicated that obesity was negatively associated with both physical and psychological components of QoL, even after accounting for obesity-related comorbidities. Individuals with obesity also had lower perceived physical and psychological working ability and more self-reported sick leave days than individuals with normal BMI.

QoL is a multidimensional concept that reflects an individual's perceptions of his/her physical, psychological, and social functioning in the context of culture norms and relative to his or her own objectives and expectancies [8]. In recent decades, the use of QoL in the assessment of benefits of medical treatments has increased [23]. The effects of obesity and weight change on QoL have been previously studied in population-based health examination studies and randomised clinical trials, using both general and obesity-specific QoL measures [10,17,24,25].

This study demonstrated that compared to individuals with normal BMI, individuals with obesity had a significantly lower overall QoL, as assessed by EUROHIS-QOL 8 measure. To estimate the clinical relevance of this finding, we calculated effect sizes (Cohen´s d) for EUROHIS-QOL 8 total score in different obesity classes vs. individuals with normal BMI [26]. Based on effect size analysis,

we found medium effect in class II (Cohen´s d=0.52) and III (0.53) obesity, and small effect in class I obesity (0.36). This supports the hypothesis that rising BMI has clinically significant, as well as statistically significant, negative association with overall QoL.

Previous studies have clearly shown that obesity has a negative impact on the physical aspects of QoL, but evidence on the association between obesity and psychological and social functioning is inconsistent [17,27,28]. Based on a Finnish cohort study, body weight was associated with physical health only [29]. In randomised clinical trials, weight loss has shown to result in improvements in physical, but not social and mental health [24]. In a meta-analysis based on eight cross-sectional studies the association with poor mental functioning was observed only in obesity class III [9]. Notably, we found that individuals with obesity rated their QoL significantly poorer in seven of the eight EUROHIS-QOL 8 components. Only satisfaction in personal relationships did not differ between individuals with obesity and normal BMI. These results clearly indicated that even mild obesity is associated with deterioration in not only physical, but also psychological health.

Some studies suggest that the impairment of QoL is stronger in women with obesity compared to men [30,31]. A previous Finnish study indicated that among healthy middle-aged individuals, physical QoL decreased with increasing level of BMI more in women than in men [32]. We found that the EUROHIS-QOL 8 score decreased consistently with rising BMI group in both sexes (with the exception of BMI ≥40 group in men). When individual EUROHIS-QOL 8 components were assessed, differences between sexes were observed especially in class II obesity. Interestingly, in class II obesity, women were more satisfied with their overall QoL, general health, themselves and their personal relationships compared to men. Thus, the study suggested that in the Finnish population,

obesity is associated with deterioration in QoL in both sexes, and in some aspects of QoL, the association is even stronger in men than women.

The concept of QoL is closely connected to an individual´s psychological and physical functional capacity and deterioration of QoL may be associated with reduced working ability and productivity. In addition to reported increase in work absence, obesity may reduce productivity while being present at work [14,33]. This study showed that a significantly lower proportion of working-age individuals with obesity considered their physical and psychological ability to work as good or fairly good, compared to individuals with normal BMI. In class II and III obesity, the number of sick-leave days, and especially the proportion of individuals with more than 14 sick leave days, was significantly higher (19% in class I and 22% in class II obesity) compared to individuals with normal BMI (12%). This is in line with previous studies indicating that obesity especially increases the risk for long sick leaves [34,35]. The results also support evidence that poor perceived working ability is a risk factor for work absence and labor market exit due to work disability [36]. However, it should be noted that work absence is also associated with socioeconomic position and that BMI groups in this study differed in certain socioeconomic variables (e.g., education level and household income) [27]. As socioeconomic variables and BMI are known to correlate, we decided not to adjust these factors in the analyses, because this could have partly masked the effect of BMI.

Overall, the associations of obesity with QoL and working ability are confounded by a complex and bidirectional network of sociodemographic and health-related factors. Based on longitudinal studies, weight-gain is not only a risk factor for lower QoL, but also vice versa [10]. Many obesity-related chronic health conditions are known to have independent negative impact on QoL, and the association of BMI and QoL is at least partly mediated by obesity-related comorbidity [18,37–39].

Recently, it has also been debated whether so called metabolically healthy obesity (BMI ≥30 but no metabolic syndrome) is a similar risk factor for health and functional decline as obesity associated with typical metabolic changes [40].

We found that after adjusting for age, sex, and obesity-related comorbidities, all obesity classes still had a significant negative association with EUROHIS-QOL 8 total score. The individual associations of class II and III obesity with EUROHIS-QOL 8 score were of similar range as the association of having one comorbidity, but the negative association of having two and three or more comorbidities were stronger than that of any obesity class alone. Of comorbidity groups considered, psychiatric disorder had clearly the largest negative association with QoL, supporting the previous evidence showing that depression has a larger effect on worsening health scores compared to the other chronic conditions [39]. Remarkably, the significant negative association between obesity and QoL was observed also in individuals without comorbidity. This supports the hypothesis that obesity is an independent risk factor for poor QoL, but the burden is further increased by the rising number of comorbidities [41].

The major advantage of randomised, population-based national cohort studies is population-representative results and a minimal selection bias compared to interventional studies. In the FinHealth study, comprehensive health information was collected from each participant, which enabled us to study the associations of a wide variety of health conditions on QoL and working ability. Noteworthy, in our study BMI groups were based on height and weight measured in health examination, in contrast to self-reporting which has the tendency of underreporting weight and overreporting height.

Some limitations should be taken into account in the interpretation of the results. The set-up of cross-sectional studies do not allow evaluating causal associations, which would require longitudinal follow-up. Data on comorbidities were based on self-reporting, which is subject to bias. In addition, the number of individuals in the class III obesity group was relatively small. Although the FinHealth study sample was formed using random sampling and weighted analysis was used, the study population was restricted to individuals whose BMI was measured in the health examination Individuals with weak physical condition are more likely to opt out in health examinations, which may cause bias and especially in high BMI classes.

The results of this study supported previous evidence indicating that obesity is negatively associated with an individual´s perceptions on broad aspects of health and working ability. Importantly, we showed that obesity was a risk factor for poor QoL even in individuals without obesity-related comorbidities. These findings strongly highlight the need for primary prevention of obesity as well as the need to perceive and treat obesity as a disease, even if the individual does not have apparent clinical comorbidity. The aim of obesity treatment should not only be to prevent comorbidities, but also to improve QoL and functional capacity. Holistic approaches, which combine new medical treatments and psychological support, are needed to tackle the increasing burden of obesity.

Declarations

Funding

Novo Nordisk Oy funded the study (collection, analyses and interpretation of the data) and writing the manuscript.

Conflicts of interest

TY is the owner of MedEngine Oy. AV, JM, and JJ are employees of MedEngine Oy. TS and KM are employees of Novo Nordisk and TS owns shares in Novo Nordisk. KP has lectured for the following pharmaceutical companies: AstraZeneca, MSD, Novo Nordisk, Sanofi, participated in advisory boards for IKEA, Novo Nordisk, Takeda, Vivus, and has received independent research grants from the following foundations: the Academy of Finland (grant numbers 272376, 314383, 266286); Finnish Medical Foundation; Gyllenberg Foundation; Finnish Diabetes Research Foundation; Sigrid Juselius Foundation; Novo Nordisk Foundation (NNF17OC0027232, NNF10OC1013354); University of Helsinki and Government Research Funds through Helsinki University Hospital. TL and AL have no competing interests.

Availability of data and material

The dataset used in this study is controlled by THL Biobank. Dataset is available for research upon research plan submission and with permission of THL Biobank.

Code availability

Not applicable.

Authors' contributions

AV, JM, TS, KM, TY, and KP designed the study. AV had primary responsibility for study conduct and was a major contributor in writing the manuscript. JM and JJ designed and performed statistical analyses. All authors participated in data interpretation and manuscript writing and read approved the final manuscript.

Ethics approval and Consent to participate

All FinHealth 2017 study participants had filled informed consent for a biobank study. The FinHealth 2017 Survey received approval from the Coordinating Ethics Committee at the Hospital District of Helsinki and Uusimaa (Ref 37/13/03/00/2016). This study was based on existing data collected in the FinHealth study complemented with data from the nationwide registers, and no new ethics

approval was required. All data used in the analyses were pseudonymous, and the permission to use the FinHealth 2017 data for this study was granted by the THL Biobank.

Consent for publication

Not applicable.

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Tables

Table 1. Characterization of the FinWeight study cohort (total), and by body mass index (BMI) category. The analyses were restricted to those who were not underweight (BMI ≥18.5).

	BMI group (kg/m²)	**Total**	**18.5–24.9**	**25.0–29.9**	**30.0–34.9**	**35.0–39.9**	**≥40.0**	**p-value**
Age (years) Mean (95% CI)	Total	49.9 (49.1–50.6)	44.4 (43.2–45.6)	53.3 (52.3–54.3)	53.6 (52.0–55.3)	49.5 (45.4–53.6)	50.9 (46.2–55.7)	<0.001
	Men	49.1 (48.0–50.1)	44.3 (42.3–46.3)	51.7 (50.2–53.2)	51.4 (49.2–53.7)	47.9 (43.9–51.9)	48.2 (36.0–60.3)	<0.001
	Women	50.6 (49.6–51.6)	44.5 (43.0–46.0)	55.3 (54.1–56.5)	56.0 (53.7–58.4)	50.5 (44.0–57.0)	52.2 (48.4–56.0)	<0.001
Sex % (95% CI)	Men	48.4 (46.8–50.1)	42.3 (39.4–45.4)	54.7 (52.4–57.1)	52.1 (48.5–55.7)	39.9 (32.7–47.5)	30.9 (20.8–43.3)	<0.001
	Women	51.6 (49.9–53.2)	57.7 (54.6–60.6)	45.3 (42.9–47.6)	47.9 (44.3–51.5)	60.1 (52.5–67.3)	69.1 (56.7–79.2)	<0.001
Level of education % (95% CI)	Elementary school, basic education	15.0 (13.8–16.4)	11.4 (9.4–13.8)	14.7 (13.2–16.3)	20.0 (16.9–23.5)	24.0 (16.0–34.3)	18.4 (9.6–32.4)	<0.001
	Lower secondary education	2.6 (2.2–3.0)	1.9 (1.4–2.5)	2.9 (2.3–3.6)	3.6 (2.6–5.0)	2.4 (1.3–4.6)	2.7 (1.0–7.2)	
	Vocational school/equivalent	28.1 (26.7–29.6)	24.2 (21.7–26.9)	29.7 (27.6–32.0)	33.8 (30.5–37.2)	26.1 (20.2–32.8)	26.2 (18.4–35.9)	
	Upper secondary education/high school	9.5 (8.2–11.0)	12.9 (10.4–15.9)	7.6 (5.7–10.2)	7.1 (5.0–10.0)	7.5 (3.8–14.6)	9.2 (4.8–16.7)	
	Non–university lower education	30.7 (29.3–32.1)	30.9 (28.4–33.5)	32.1 (30.0–34.2)	26.6 (23.8–29.6)	31.5 (25.6–38.2)	35.5 (26.3–46.0)	
	Master's Degree (university degree. MA or similar)	14.0 (13.1–15.0)	18.8 (16.9–20.8)	13.0 (11.6–14.6)	8.9 (7.3–10.9)	8.4 (5.6–12.5)	8.0 (4.2–14.5)	
Marital status % (95% CI)	Single	19.2 (17.5–21.0)	25.7 (22.5–29.2)	12.9 (11.1–15.1)	16.9 (13.4–21.1)	25.3 (16.6–36.5)	21.1 (11.4–35.7)	<0.001

	Married / registered partnership	66.5 (64.7–68.2)	62.9 (59.7–66.0)	71.8 (69.4–74.0)	65.7 (61.8–69.4)	57.7 (48.9–66.1)	61.0 (49.0–71.8)	
	Separated / divorced / widow	14.4 (13.4–15.3)	11.4 (10.0–12.9)	15.3 (13.8–16.9)	17.4 (15.1–20.1)	17.0 (13.0–21.9)	17.9 (11.6–26.5)	
Employment status % (95% CI)	Employed or self-employed	51.1 (49.4–52.7)	52.9 (49.9–56.0)	52.1 (49.7–54.6)	47.1 (43.5–50.7)	46.5 (38.8–54.3)	44.9 (34.6–55.6)	<0.001
	Unemployed	7.2 (6.2–8.2)	8.6 (6.7–11.1)	4.8 (3.9–5.9)	8.4 (6.4–10.9)	8.8 (5.7–13.4)	9.8 (5.3–17.3)	
	Student, further education or unpaid internship	9.4 (7.8–11.2)	14.2 (11.3–17.7)	5.0 (3.4–7.4)	6.9 (4.1–11.4)	13.4 (5.9–27.5)	12.9 (5.1–29.0)	
	Retired	28.5 (27.2–29.8)	20.0 (18.2–21.9)	34.0 (32.0–36.2)	34.1 (31.0–37.4)	28.3 (22.9–34.5)	27.6 (19.9–36.9)	
	On family leave or stay at home	3.9 (3.4–4.6)	4.2 (3.3–5.3)	4.0 (3.0–5.2)	3.5 (2.4–5.0)	3.0 (1.6–5.7)	4.8 (1.9–11.3)	
Household income % (95% CI)	Less than < 25 000 €	25.9 (24.3–27.6)	27.7 (24.6–31.0)	21.1 (19.1–23.4)	27.3 (24.1–30.7)	36.2 (27.6–45.9)	43.3 (32.2–55.2)	<0.001
	25 001–50 000€	33.8 (32.2–35.3)	30.0 (27.6–32.6)	37.4 (35.0–39.9)	34.7 (31.2–38.4)	32.4 (26.2–39.2)	28.6 (20.4–38.5)	
	50 001–80 000€	24.8 (23.5–26.2)	24.8 (22.5–27.3)	25.5 (23.6–27.6)	25.4 (22.5–28.5)	20.3 (15.6–26.0)	19.1 (12.4–28.1)	
	>80 000€	15.5 (14.4–16.7)	17.4 (15.3–19.6)	15.9 (14.4–17.6)	12.7 (10.1–15.7)	11.1 (7.8–15.5)	9.0 (4.9–16.0)	

The p-values for the BMI group comparisons are unadjusted. CI, confidence interval

Figure legends

Fig. 1 Analysis of EUROHIS-QOL 8 total score a) EUROHIS-QOL 8 total score in different BMI categories. The figure shows unadjusted point estimates and 95% confidence intervals, together with age and sex adjusted p-values compared to individuals with normal BMI. b) The association of EUROHIS-QOL 8 total score with comorbidities and body mass index (BMI). The figure shows regression coefficients (point estimate (95% confidence interval); p-value) estimated using two different linear regression models. The first model was adjusted for BMI (18.0–24.9 kg/m^2 as the reference), demographics (age as a continuous variable, sex (man vs. woman) and comorbidities (yes vs. no)). In the second model, individual comorbidities were replaced by count of different comorbidities being present (0 as the reference, 1, 2, 3 or more). The presented results for BMI, age, sex and each of the comorbidities (cardiovascular disease, cancer, musculoskeletal disease, psychiatric disorder, respiratory disease, sleep apnea) are from the first model. For the second model, the results are presented for the number of comorbidities present only.

The analyses were restricted to the subgroup of individuals who had at least seven of the potential eight EUROHIS-QOL 8 components available.

Fig. 2 The percentage of individuals with good or very good QoL in each EUROHIS-QOL 8 component in individuals who had at least seven of the potential eight EUROHIS-QOL 8 components available. The figure shows unadjusted point estimates and 95% confidence intervals, together with age and sex adjusted p-values, comparisons to individuals with normal BMI (18.5–24.9 kg/m^2). The analysis was restricted to the subgroup of individuals who had at least seven of the potential eight EUROHIS-QOL 8 components available.

Fig. 3 Working ability and work absence in different BMI groups For physical and psychological working ability, the respective panels a) and b) show the proportion of patients who rated their ability as good or very good. For work absenteeism, panel c) shows the number of self-reported

days in the past 12 months. Additionally, the proportion of patients with over 14 self-reported work absence days is shown in panel d). The presented point estimates and confidence intervals are unadjusted, and p-values are adjusted for age and sex, comparisons are made to BMI group 18.5–24.9 kg/m^2. The working ability analyses were restricted to those in the working age (20–64 years), and work absence analyses to those who were also employed or self-employed.