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Associations of selected aspects of socioeconomic status with overweight and obesity in women with breast cancer and a population-based control group.

Quantitative data analysis using data from the MARIE-study baseline

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Abstract

Introduction: Breast cancer is the most common malignant tumour among women. Each year it affects about 2.1 million women worldwide, and the lifelong risk for development is approximately 12%. Though previous research has documented risk factors which contribute to the development of breast cancer, the potential influence of socioeconomic status and its related factors is only recently getting more attention. As maintaining a healthy weight is one of the recommended main preventive actions, this thesis examined the associations of the selected SES aspects marital status, relationship status, education level and autonomy in occupation level with overweight and obesity, in breast cancer patients and a population-based control group.

Methods: The analyses were performed with the baseline data of the MARIE-study, a population-based case-control study, which was assessed between 2002 and 2005 in the regions of Hamburg and Rhein-Neckar-Karlsruhe. The sample comprises of 10,882 female participants, aged between 50-74 years. The statistical analyses included bivariate and in the form of binary logistic regression analysis, multivariate methods. The tests were run using SPSS version 25.

Results: The results showed that individuals of the case and control groups with the lowest education level had significantly increased odds of overweight and obesity when compared to the highest education level (i.e. OR for breast cancer patients: 3.52, 95% CI 2.87-4.32). The autonomy in occupation level presented similar findings (i.e. OR for obesity in controls: 1.95, 95% CI 1.65-2.30), where it could be observed that the lower the category, the higher the odds of being overweight and obese. Relationship status and marital status presented inconclusive findings, with partly significant results in the individual categories.

Conclusion: A low education level and low autonomy in occupation level were associated with overweight and obesity. Comparison of the BCP and population-based control group's results showed no striking differences. Partial aspects of the socioeconomic status, i.e. income, and other behavioural factors, as well as the general health status, were not considered in this work and could offer an approach for further investigations. This thesis may serve as a starting point for future research where, i.e. in the context of SES aspects and overweight/ obesity, the survival of BCP could be focused on.

K E Y W O R D S

Socioeconomic status, case-control study, overweight, obesity, breast cancer

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List of Acronyms

BC	Breast Cancer
BCP	Breast Cancer Patients
BL	Baseline
CI	confidence interval
DV	Dependent Variable
IV	Independent Variable
LSF	Lifestyle factors
MARIE	**Ma**mmakarzinom-**Ri**sikofaktoren-**E**rhebung
Mdn	Median
MET	Metabolic equivalent of task
OR	Odds ratio
PAF	Population Attributable Fraction
r_s	Correlation Coefficient
SD	Standard deviation
SES	Socioeconomic status
SPSS	Statistical Package for the Social Sciences
V	Cramer-V
WCRF	World Cancer Research Fund
WHO	World Health Organisation

1 Introduction

Breast cancer (BC) is the most common malignant tumour amongst women, and the life-long risk of developing it is about 12% (WHO, 2014). The WHO (2014) found that the incidence for women who had developed the malignant BC form in 2013 was 71623 in Germany (0.17% of the 41,210,000 female population). There are many risk factors documented to contribute to the development of breast cancer. Though previous research has shown an impact of socioeconomic status (SES) on health inequalities, the potential influence on breast cancer and its related factors is poorly investigated and only recently getting more attention (Riba et al., 2019).

Breast Cancer Epidemiology. Breast cancer affects about 2.1 million women worldwide, each year, and represents the cancer type with the highest incidence and mortality in women (WHO, 2019a). In Germany, 104,300 women were living with BC in 2013. The overall mortality from BC was 18.8%, which amounts to 19,608 breast cancer deaths (WHO, 2014).

Early detection of the tumour is critical to improve both the outcome and survival. The most common first symptom is a palpable indolent resistance in the breast, which shows the importance of health education to promote self-palpation, overall body awareness and use of health services, i.e. BC screening. Besides the self-exam, the clinical breast exam, where a trained health professional palpates both breasts in regular intervals to detect abnormalities at an early stage, is part of the mentioned screening process. Mammography is another component of breast cancer screening in high resource settings. Germany follows the WHO recommendation to screen women aged 50 to 69 in an organised, population-based approach. Mammography uses low energy x-ray to identify abnormalities in the breast tissue, and research has found that this method reduces breast cancer mortality by approximately 20% (WHO, 2019a; 2019c).

Studies have identified several factors which increase the risk of developing BC. Amongst those are genetic risk factors like the BRCA1 and BRCA2 genes, and reproductive risk factors, like late age at first childbirth (DKFZ and UKE, 2011). Danaei et al. (2005) found that several behavioural and modifiable risk factors contribute to the burden of disease as well. They concluded that obesity and overweight (Population attributable fraction (PAF) 13%) was the most crucial contributor in high-income countries, with alcohol use (PAF 9%) and physical inactivity (PAF 9%) following close behind. A study focusing on BC survival found that a high BMI (≥30) was the lifestyle risk factor that affected survival the most (HR 1.38; 1.02-1.86), compared to women with a BMI <25 (Dal Maso et al., 2008).

Socioeconomic status and breast cancer. The term socioeconomic status is used to describe an individual's position in a social structure marked by social inequality. There are several other expressions, i.e. socioeconomic position, that serve a similar purpose, meaning that an umbrella term is used to combine several socioeconomic aspects. In this thesis, to maintain consistency, the term socioeconomic status is used. It is commonly defined via educational level, occupational status, and monetary income. However, the exact definition and measurement of SES in epidemiologic studies is heterogeneous. In studies where information about income, social status, and class is not available, education level might be used as an indicator of social position, as earlier findings showed a tendency of education correlating with the other SES aspects. Depending on the study region other factors like ethnicity might be a major aspect (d'Errico et al., 2017; Lampert and Kroll, 2009). Research results largely agree that people with low SES (defined by education, occupation, autonomy in occupation, net equivalent income and calculated using the SES index) have a higher risk of developing chronic diseases and conditions (i.e. type 2 diabetes mellitus OR 3.13; 1.89-5.19 in women with low SES vs. high SES) (Lampert and Kroll, 2013). Socioeconomic differences are also reflected in the distribution of behavioural risk factors such as smoking, alcohol consumption, lack of physical activity and obesity. The greater prevalence of diseases, health impairments, and the underlying risk factors ultimately result in higher premature mortality and reduced life expectancy in individuals with lower SES (Foster et al., 2018).

Larsen et al. (2011) found that a higher SES (defined through education, income, occupation) is associated with a higher incidence of postmenopausal BC. The association was mediated by differences in exposure to reproductive factors, hormone replacement therapy, and alcohol consumption. Those findings were supported by another research team, whose objective it was to investigate the association between SES and breast cancer outcomes in Europe (Lundqvist et al., 2016). They similarly found that women with higher SES (defined by education, occupation, family occupation, income) showed a significantly higher incidence (SRR 1.25; 1.17-1.32) for breast cancer, possibly due to higher attendance of mammography screenings. A lower case fatality for women with a higher SES was observed, which might be explained by differences in comorbidity, lifestyle factors, treatment factors, and tumour characteristics. Inversely, several factors, like the lower attendance of mammography screening for women with lower SES, were linked to breast cancer risk and outcome which are relevant targets for policy intervention to lower socioeconomic inequalities in health outcomes (Lundqvist et al., 2016).

A study by Riba et al. (2019) concluded that socioeconomic inequalities do exist in breast cancer care. Among other things, they noted that women with a lower income (below $63,000/year) more often got a mastectomy (OR 1.09 1.08-1.10) and were less likely to receive an immediate breast reconstruction (OR 0.52; 0.51-0.52) compared to women with higher income. Investigating socioeconomic inequality in respect of breast cancer survival, an Australian research team found that there was a distinct increase of odds looking from the least disadvantaged quintile at the four other categories. The result was that the most disadvantaged quintile presented significantly worse (OR 1.31; 1.07-1.69) survival rates (Dasgupta et al., 2012). Focusing on mortality and recurrence, a lower SES (defined by education, occupation, autonomy of occupation and in selected studies area-level socioeconomic disadvantages and ethnicity) was associated with higher BC mortality (Ho-Huynh et al., 2019).

Body mass index. Overweight and obesity are a risk factor for chronic conditions like type two diabetes mellitus, hypertension and coronary heart disease. In most countries, the rates of overweight and obesity have risen (WHO, 2019d). The BMI is the standard measure of overweight and obesity, and classification is commonly based on the categories suggested in the World Health Organisation guidelines (WHO, 2019b). A systematic review (including 14 studies) focused on the relationship of life-course SES with obesity (BMI>30) found that women with low life-course SES had 1.35 higher (CI 1.04-1.76) odds of being obese than the high life-course SES women (Newton et al., 2017). Foster et al. (2018) found that the combination of a low SES (defined by Townsend deprivation index, education, occupation, household income), overweight (BMI >25) and an unhealthy life-style was associated with lower overall health status. Supporting those findings, another research team discovered that women with a low SES (defined through educational attainment and employment status) were more likely to exceed alcohol use guidelines (OR 3.86, 1.23-12.10), smoke (OR 1.68, 1.01-2.8) and have poor nutritional habits (OR 1.59, 1.17-2.16), compared to women with a higher SES (Akinyemiju et al., 2017). Considering these findings Lord et al. (2015) found, that negative health behaviours, for example less physical activity, fruit and vegetable intake, and high screen time, were associated with lower-income neighbourhoods (defined by median household income, % of low income cut-offs, rural/urban status, education) and a higher adiposity rate, which underlines the link between SES, behavioural factors and BMI. The main finding of the DEGS1 study was that the lower the SES (defined through the SES index), the higher the risk of health impairment. Similarly, the DEGS1 study revealed significantly increased odds of obesity (OR 4.39, 3.15-6.12) in women with low SES compared to high SES. Looking at behavioural factors, women with low SES, were more frequently physically inactive compared to women with high SES (OR 3.99, 2.94-5.41) (Lampert et al., 2013).

A study that looked into the individual SES aspects found that the chance of being overweight was 1.48 times (CI 1.3-1.69) higher among people with a low level of education compared to people with a high level of education (Marija et al., 2018). Those findings were supported by further study results, which found that the lower the educational level, the higher the chance of being overweight or obese. The same study also analysed the effects of occupation and employment and concluded that the chance of being overweight or obese was 1.87 times (CI 1.28-2.74) higher for women who were manual labourers or employees than for women in management positions or intermediate professions (Vernay et al., 2009). The following studies investigated associations of marital and relationship status with overweight/obesity and other behavioural factors. Hilz and Wagner (2018) found that for example, the status of being married can have a protective effect on smoking habits, as in the partner is less likely to smoke, and adverse effects, as in weight gain, on the body weight. Another study found that the odds of being overweight were 1.13 times (CI 0.86-1.47) higher when divorced compared to married women. The preceding sentences demonstrate that studies that examine marital status and body weight tend to have inconsistent findings. The varying results may well be explainable by the study type and whether conditions such as marital status transitions and the participant's sex were taken into account (Sobal et al., 2009; Teachman, 2016).

Dieterich et al. (2014) found a positive association between higher BMI, defined as obesity, and BC incidence. Those findings concerned primarily adult weight gain, an assumption which was further supported by other researchers who added that weight loss to the normal category acts inversely (Lundqvist et al., 2016). A BMI in the overweight and obese category has further been linked to a worse BC prognosis and increased mortality (Lundqvist et al., 2016; Vogel et al., 2018). Recommendations to reduce the risk of BC target behaviour in order to make positive health choices. Maintaining a healthy weight, being physically active and choosing a healthy diet is the recommended main goal as preventive action (WCRF, 2018).

Rationale. Breast cancer challenges the scientific world with its diverse nature, multitude and complex aetiology. The research question was formed after investigating the existing literature regarding BC and discovering a sparse inclusion of work researching the associations of SES with overweight and obesity in breast cancer patients. Though there is much research concerning the incidence and mortality of BC, as an outcome, the search for possible predictors was mostly focused on genetic factors and hormone therapy. Expanding the research topics and investigating SES as a predictor and overweight/ obesity as an outcome, most studies concurred that there is a link to be found. Several findings suggested an association between SES and behavioural factors, like nutritional habits and physical activity, as well as the association of behavioural factors with the BMI.

Considering cancer prevention recommendations, i.e. WCRF (2018), which state that maintaining a healthy weight is one of the main preventive actions for BC, the importance is clear. In order to gain a deeper understanding of SES factors and overweight/obesity in breast cancer patients and 'healthy' controls, this thesis aims at analysing respective population data. Baseline data of the MARIE-study provided a temporarily limited insight into a particular population and can, therefore, be seen as a starting point for future research where, in the context of SES aspects and overweight/obesity, a look is taken into the survival of BCP.

2 Research Question

The research question investigated in this thesis is based on the substantiated hypothesis that the SES – and certain aspects thereof – has an impact on overweight and obesity. Particularly, the hypothesis is that a lower SES is associated with higher levels of overweight and obesity.

Thus far, no published study has researched the associations between aspects of SES with overweight and obesity in a population that comprises both breast cancer patients and a population-based comparison group. Therefore, the overall aim of this thesis was to gain deeper insight into the associations between aspects of SES with overweight and obesity in certain population groups, particularly comparing women with breast cancer with an age-matched breast cancer free control group using data from a large population-based case-control study.

Statistical analysis will determine whether the selected factors are related to overweight and obesity in the two groups studied. The following main research question will be examined: Is there an association of the selected SES aspects marital status, relationship status, education level and autonomy in occupation level with overweight and obesity in breast cancer patients and population-based controls?

The main hypothesis derived from the research question is:

The selected SES aspects *marital status, relationship status, education level* and *autonomy in occupation level* are associated with overweight and obesity in breast cancer patients and population-based controls.

Regarding the specific direction of these associations, the following hypotheses were generated:

(1) Women with or without breast cancer who are not married are more likely to be overweight.
(2) Women with or without breast cancer who are not married are more likely to be obese.

(3) Women with or without breast cancer who are not in a relationship are more likely to be overweight.
(4) Women with or without breast cancer who are not in a relationship are more likely to be obese.
(5) Women with or without breast cancer who have a low education level are more likely to be overweight.
(6) Women with or without breast cancer who have a low education level are more likely to be obese.
(7) Women with or without breast cancer who have a low autonomy in occupation level are more likely to be overweight.
(8) Women with or without breast cancer who have a low autonomy in occupation level are more likely to be obese.

The hypotheses are statistically tested by bivariate and multivariate analyses.

3 Methodology

To answer the research question, the baseline data from the German MARIE-study was analysed, which was provided by the MARIE research team. Following, this chapter will provide details about the MARIE-study and assessment of variables relevant to this work, as well as a description of the data analysis methods.

3.1 Study population

The MARIE-study is a population-based case-control study conducted in Hamburg and the Rhein-Neckar-Karlsruhe region to identify potential risk factors for the development of breast cancer. Between 2002 and 2005 (baseline), 3,813 peri- and postmenopausal breast cancer patients, aged 50-74 years at diagnosis with an incident histologically confirmed invasive breast cancer (ICD-10 C50, stage I to IV) or *in situ* tumour (D05, stage 0), were enrolled in the study. Controls were randomly drawn from lists of residents provided by the population registries and were matched two controls to each case based on birth year and study region (DKFZ and UKE, 2009). Enrolment in the study was restricted to women residing in the study regions. Furthermore, they had to be able to speak German and participate in a personal interview of about an hour and a half which required a basic level of physical and mental fitness (Flesch-Janys et al., 2008). To this day there have been two follow-ups for the cases and controls, with the third follow-up in preparation and planned for late 2019.

3.2 Data assessment

The baseline interviews were conducted by trained personnel in a face-to-face setting using a standardised questionnaire. Different sections tried to encompass all known or suspected risk factors of BC. The 102 questions covered demographic and socioeconomic factors as well as lifestyle factors (e.g. physical activity, smoking habits and alcohol consumption), and questions concerning body measurements. There were detailed questions about the participants' medical history, as well as the family's (Slanger et al., 2007).

As the focus of this work is to analyse associations of selected aspects of socioeconomic status with overweight and obesity in BCP and a population-based control group, a closer look as to how the respective information was assessed is provided in the following sections.

3.2.1 Socioeconomic status (Independent Variables)

The interview included several questions concerning marital and relationship status, as well as the history of education and occupation. The information was used to get an impression of the particular SES aspects.

Jöckel et al. (1998) developed a concept for the collection and evaluation of SES for use in research. The concept was adapted during the MARIE-study data collection. To ensure comparability with other empirical and epidemiological studies, standard demographic survey questions were included. Thus, information about the age, marital and relationship status, education and occupation were gathered.

For marital status, the questionnaire provided the answer options married, single, separated, divorced and widowed. The question was followed up with a dichotomous yes/no question which related to the participant's relationship status, as in does the participant have a partner or not. The questions about the marital and relationship status were not only included in this work to ensure general comparability with other studies' survey tools but also to take findings from other research into consideration.

The education variable combines information about school education, higher education and vocational training, and categorises the participants into three levels of education. An overview of how the different educational achievements were categorised can be found in Appendix A, but as an example, a medium level was assigned when a middle school leaving certificate and vocational training was achieved or a high school leaving certificate and vocational training was completed (Jöckel et al., 1998).

Autonomy in occupation was assessed through standardised questions about the occupation title, occupation description and leadership responsibilities, which are coded and sorted into different categories. It is categorised into three levels and is an integral part of the

SES (Lampert and Kroll, 2009). As an example, a low autonomy in occupation level would be assigned if the participant was an untrained or semi-skilled labourer, a civil servant in the lower grade, an employee with basic tasks, a skilled labourer or an agriculturist with less than 10 ha. For further information on how the different occupations and responsibilities were categorised into 'autonomy in occupation' see Appendix A (Hoffmeyer-Zlotnik, 2003).

Table 1: List of variables

Variable name	Label	Data level	Codes
Caco	Cases and Controls	Nominal	0=controls 1=cases
Familienstand	Marital status	Nominal	1=married 2=single 3=separated 4=divorced 5=widowed
Lebensgem	Relationship status	Nominal	0=partner no 1=partner yes
Educ	Education	Ordinal	1=low 2=medium 3=high
Occup3	Autonomy in occupation	Ordinal	1=low 2=medium 3=high
BMI_jetzt	Body mass index	Metric	
BMI_who	Adult BMI in WHO categories	Nominal	1=0-<18.5 0=18.5-<25 2=25-<30 3=≥30
BMI_overweight_dichot	BMI <25 vs. ≥25	Nominal	0=<25 1=≥25
BMI_obese_dichot	BMI <30 vs. ≥30	Nominal	0=<30 1=≥30
alterint	Participant's age at interview	Metric	
Alkgrr	Alcohol consumption in last phase (g/day)	Metric	
Rauchstatus	Smoking status	Nominal	0=non smoker 1=ex-smoker 2=current smoker
Total_pa50	Sum (walking, cycling, sports, occupational, household PA)	Metric	Mets*h per week

Source: Own representation.

3.2.2 Body mass index (Dependent Variables)

The BMI, defined as body weight (kg) / (height $(m)^2$), was calculated based on self-reported information on weight and height. For descriptive purposes, it was categorised into normal weight (18.5-<25kg/m^2), underweight (<18.5 kg/m^2), overweight (25 - <30 kg/m^2) and obese (>30 kg/m^2) according to the World Health Organisation guidelines (WHO, 2019b). In order to further analyse the association of SES with the outcomes overweight and obesity using binary logistic regression, the BMI was dichotomised at the cut-off points for overweight (BMI ≥25 vs. <25) and obesity (BMI ≥30 vs. <30).

3.2.3 Covariates

The following variables were considered to be related to the selected SES aspects, overweight and obesity. Therefore, the possible influence was investigated and adjusted for during statistical analyses in order to address potential confounding.

Information about the participants' age, smoking status and habits, as well as alcohol consumption and physical activity, was collected. The queries to all these topics were very detailed to get an idea about the participants' behavioural factors spanning up to five decades (Slanger et al., 2009).

Participants' alcohol consumption in gram per day was calculated from collected data, for example by asking how much of a certain type of alcohol (e.g. beer, wine, spirits) was consumed on average (daily/weekly/monthly) during a certain timespan, i.e. ages 30-50, from age 50. The variable used in the analysis of this work refers to the average alcohol consumption (g/day) of the most recent timespan, according to the participant's age.

Participants' current smoking status at baseline, as shown in table 1, was categorised into the groups 'non-smoker', 'ex-smoker' and 'current smoker' and hence analysed as a nominal data level variable.

To analyse physical activity on a metric data level, metabolic equivalents of tasks (METs) were calculated, which summed up the self-reported participation in sports, walking and cycling as well as occupational and household tasks. The participants were asked how many minutes and hours were spent per week on the various activities from the age of 50 until the baseline interview. The activities were evaluated and to calculate the MET-hours per week multiplied with the individual intensity score (e.g. cycling: 6.0 MET; jogging: 7.0 MET; walking: 4.0 MET) (Ainsworth et al., 2011).

3.3 Statistical Analysis

All data were analysed using IBM's statistical package for social sciences (SPSS) version 25.

As ascertained in the previous section, the variables included in the analysis were either on a nominal, ordinal or metric data level. As the baseline represents one measurement time-point, appropriate tests were chosen to analyse the data. A table with the complete dependence analysis plan can be found in Appendix B. Participants with missing data on exposure, outcome and covariates were excluded from the analysis. All statistical testing was performed two-sided, and the statistical significance level was determined as $\alpha=0.05$.

3.3.1 Descriptive Analysis

In order to get a first overview of the data, controls and cases were analysed descriptively. Frequency distributions were calculated, and graphs were created for visual inspection (i.e. normal distribution). Measures of central tendency, standard deviation and other measures of statistical dispersion were calculated for the variables age, BMI, alcohol consumption and physical activity, which have a metric data level. Though a visual check was also performed, the central limit theorem states, that the larger a sample, the more likely it is that there will be an approximately normal distribution. Large samples are usually defined as n=>30, which applies to all subsequent analyses so that a normal distribution is assumed for all tests (Field, 2013).

3.3.2 Bivariate Analysis

The following bivariate analysis investigated associations of two variables. Pearson's Chi-square test was used to determine the probability of independence of the different nominal SES aspects and the dichotomous variables overweight and obese. The test was run for each case and control group. To measure the strength of association, Cramer-V (V) was used, while considering that if the effect was less than 0.1 the association between the two variables was very small. To test the correlation between two variables of at least ordinal or metric data level, Spearman's rank correlation test was chosen. To test the strength of association, the correlation coefficient (r_S) was calculated, which describes the direction and size of a linear relationship between two variables. It ranges from -1.0 to +1.0 with 0 meaning there is no existing relationship between the tested variables (Goodwin and Leech, 2006). As literature suggested an association between alcohol consumption and smoking status the nonparametric Kruskal-Wallis test was chosen, as the samples failed tests of variance homogeneity and thus the prerequisite for the analysis of variance were not fulfilled (Whitfield et al., 2018). Using the Kruskal-Wallis test, the question was answered if the central tendencies of the different independent samples differ. Because of the differences of the group sizes, the effect size was calculated using Cohen's d.

3.3.3 Multivariate Analysis

The binary logistic regression analysis was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) of overweight or obesity in dependence of the SES aspects a) marital status (married (reference), single, separated, divorced, widowed), b) relationship status (partner no, partner yes (reference)), c) education (low level, medium level, high level (reference)) and d) autonomy in occupation (low level, medium level, high level (reference)). The analysis was intended to illustrate the nonlinear relationship between the independent variables and the probabilities of occurrence of the outcome.

Since the aim was a comparison between the BC patients and the population-based controls, analyses were conducted stratified by case status. A prerequisite for performing the analysis was a dichotomous dependent variable (DV), in this case, overweight (yes/no) and obesity (yes/no) respectively. The reference categories defined in the independent variables (IVs) were intended to indicate the direction for comparison within the groups (Field, 2013).

As this thesis works with four IVs, the interaction effect of the SES aspects with each other was tested to decide if the variables had to be included in the respective models (Field, 2013).

In addition to estimating crude odds ratios, potential confounding was addressed by adjusting for age at interview (metric), alcohol consumption (g/day, metric), physical activity (METs*h/week, metric) and smoking status (non-smoker/ex-smoker/current smoker, nominal). The relationships between the possible confounders, IVs and DVs, were tested in the bivariate section, thus, no further examination was necessary at this point. For the interpretation of the results, the odds ratios of the crude and adjusted models were compared.

The models' goodness of fit and validity has been verified with a sequence of tests, starting with the Omnibus test which calculated a Chi^2 and the models' significance. The Omnibus test checks whether the model as a whole makes an explanatory contribution by comparing the regression model with the test's base model, which in this case only takes the constant into account. A statistically significant result indicates a difference between the base model and the regression model with which the analysis can be continued. Nagelkerkes R^2 was calculated to test how well the models fit the data. Nagelkerkes R^2 can result in values between null and one, whereby the rule states that the closer one is approached, the better the model fits the data (Field, 2013).

4. Results

The following section presents the results of the abovementioned statistical analyses, beginning with the descriptive section and following with the results of the dependence analyses.

4.1 Characteristics of the sample

The total analysis sample consists of n=10,882 women, after excluding 211 participants due to missing values for any of the included variables. Due to the study inclusion criteria, all participants were women with a mean age of 63 years, ranging from 50 to 79 years. 65.8% (n=7159) of the included women were controls and 34.2% (n=3723) were breast cancer cases (table 2).

As shown in table 2, 65.6% (n=7139) of the women stated that they were married at the time of assessment. The second-highest percentage (approx. 15%), for both groups, was in the widowed category. In total, 70.6% (n=7686) of the participants claimed to be in a relationship, which differed only slightly in both case and control group.

More than half of the women (57.2%; n=6223) were in the low education group, and 14.6% (n=1594) qualified for the high education category. Calculations for the autonomy in occupation variable indicated that 35.9% (n=3906) of the women had a low standing at their work setting. The mean BMI was 26.1 (Mdn 25.4; SD 4.7) with 44.5% (n=4841) grouped into the normal weight category by WHO standards. 36.0% (n=3916) were overweight and 18.2% (n=1980) of the participants were grouped into the obese category. The mean alcohol consumption amounted to 8.4 gram per day (Mdn 3.3; SD 14.8). 52.0% (n=5657) of the women stated that they were non-smokers, and the mean for physical activity was 180.2 METs per week (Mdn 168.6; SD 71.0).

Comparing the descriptive results, the BCP and population-based control group presented only slight differences. Focussing on the body weight, the controls were more frequently obese than the cases (18.9%; n=1356 vs. 16.8%; n=624), while a slightly lower percentage was categorised as normal weight.

Table 2: Characteristics of selected MARIE-study variables

N %	Controls 7159	 65.8%	Cases 3723	 34.2%	Total 10882	 100%
Age mean	63 (Mdn:63; SD:6)		63 (Mdn:63; SD:6)		63 (Mdn:63, SD:6)	
Marital status						
married	4726	66.0%	2413	64.8%	7139	65.6%
single	402	5.6%	233	6.3%	635	5.8%
separated	100	1.4%	56	1.5%	156	1.4%
divorced	849	11.9%	462	12.4%	1311	12.0%
widowed	1082	15.1%	559	15.0%	1641	15.1%
Relationship status						
partner no	2096	29.3%	1100	29.5%	3196	29.4%
partner yes	5063	70.7%	2623	70.5%	7686	70.6%
Education level						
low	4088	57.1%	2135	57.3%	6223	57.2%
medium	2028	28.3%	1037	27.9%	3065	28.2%
high	1043	14.6%	551	14.8%	1594	14.6%
Autonomy in occupation						
low	2564	35.8%	1342	36.0%	3906	35.9%
medium	2812	39.3%	1468	39.4%	4280	39.3%
high	1783	24.9%	913	24.5%	2696	24.8%
BMI mean	26.2 (Mdn:25.4; SD:4.7)		25.9 (Mdn:25.3; SD:4.4)		26.1 (Mdn:25.4; SD:4.7)	
18,5-<25 (normal)	3144	43.9%	1697	45.6%	4841	44.5%
0-<18,5 (under)	98	1.4%	47	1.3%	145	1.3%
25-<30 (over)	2561	35.8%	1355	36.4%	3916	36.0%
≥30 (obese)	1356	18.9%	624	16.8%	1980	18.2%
Alcohol consumption mean	8.4 (Mdn: 3.3 SD:13.5)		8.5 (Mdn:3.3 SD: 17.1)		8.4 (Mdn:3.3; SD:14.8)	
Smoking status						
non-smoker	3687	51.5%	1970	52.9%	5657	52.0%
ex-smoker	2078	29.0%	1026	27.6%	3104	28.5%
current smoker	1394	19.5%	727	19.5%	2121	19.5%
PA in MET*h/week mean	181.7 (Mdn:170; SD:71.7)		177.2 (Mdn:165.9; SD:69.5)		180,2 (Mdn:168.6; SD:71.0)	

Source: Own calculation and representation.

4.2 Bivariate Analyses

The following section describes the bivariate relationships between the selected SES aspects, marital status, relationship status, education level and autonomy in occupation level, with overweight and obesity which are examined for case and control group. Furthermore, correlations and the results of the Kruskal-Wallis test are presented for the aforementioned variables as well as for the covariates. In addition, the effect sizes are determined.

Crosstabulation was used to evaluate the occurrence of overweight and obesity within individual groups, combined with the identification of notable differences and similarities between case and control group.
In the group of BCP, 53.6% (n=1294) of the married women had a BMI in the overweight category. As presented in figure 1, the results, while almost similar for both case and control group, showed that over 50% of the women were overweight. Women who indicated to live separated showed the most different results between cases and controls, with 39.3% (n=22) of the BCP and 53% (n=53) of the control group being overweight. The highest percentage was reached in the widowed group. The BCP were 59.6% (n=333) overweight, and the control group exceeded that result with 63.2% (n=684). A consistent observation was that the overweight percentages of the control group exceeded the BCP in all categories.

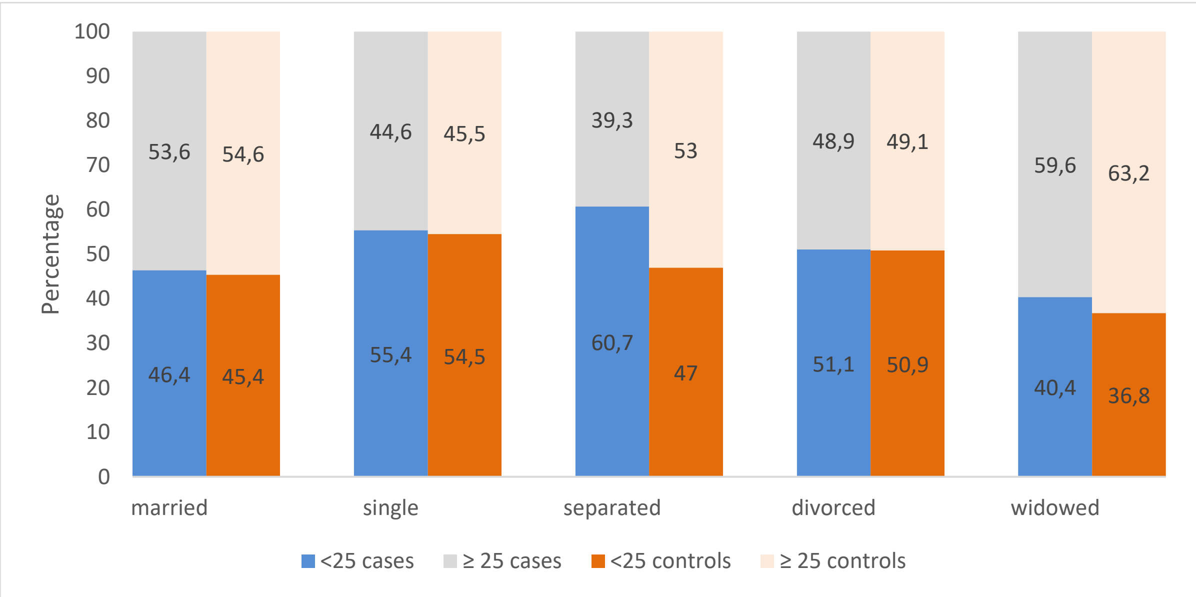

Figure 1: Distribution of overweight (BMI ≥25) by marital status in breast cancer patients and controls
Source: Own calculation and representation.

The cut-off point obesity presented its greatest difference between cases and controls in the separated group. 12.5% (n=7) of the cases and 21% (n=21) of the control group were obese. In both the BCP (21.1%; n=118) and population-based control group (24.5%; n=265), the widowed women had the highest amount of obese people in comparison to the other marital status groups. As shown in figure two, the population-based control group exceeded the BCP, percentage-wise, in all marital status groups.

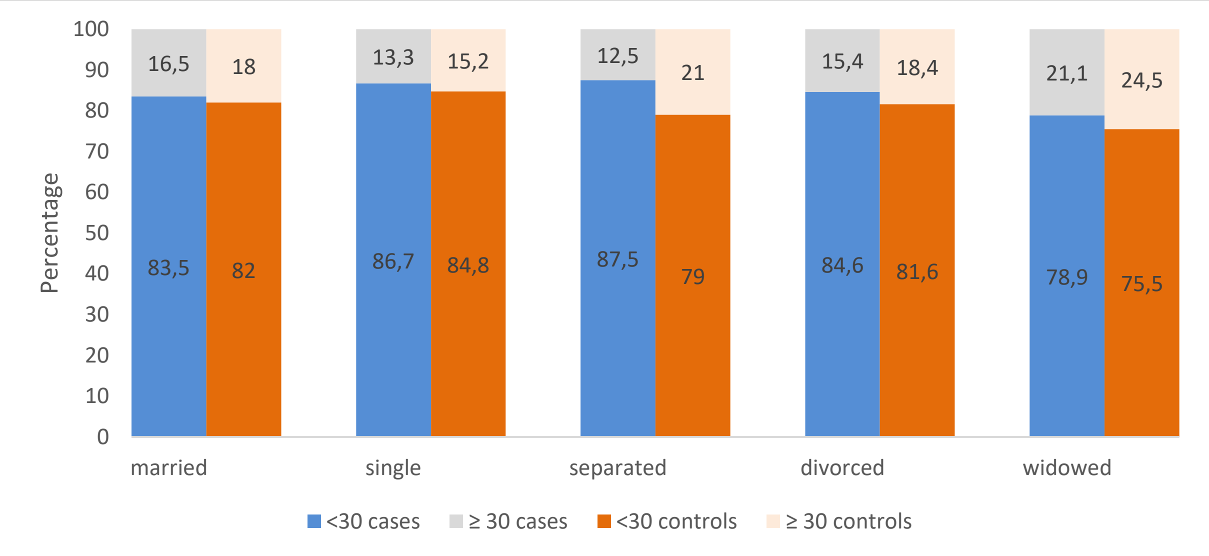

Figure 2: Distribution of obesity (BMI ≥30) by marital status in breast cancer patients and controls
Source: Own calculation and representation.

In the next step, the relationship status was analysed. It documented whether the women had a partner or not, and the result showed that the distribution for both BCP and population-based controls, regarding overweight, were almost the same. The BCP with no partner were 52.5% (n=578) classified as overweight, in comparison to the BCP with a partner (n=1401) who were 53.4% overweight. The control group achieved for the partner no (n=1146) and partner yes (n=2771) categories 54.7%, respectively. The population-based control group, who stated that they had *no partner,* were 21% (n=441) in the obese category compared to the 202 BCP, which amounted to 18.4% (shown in figure 3).

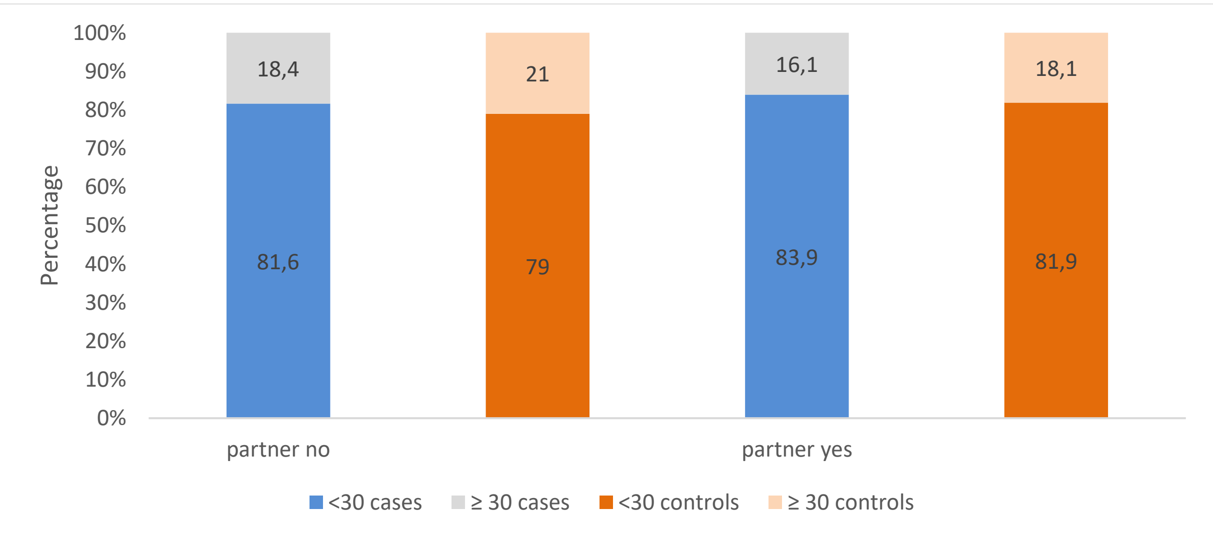

Figure 3: Distribution of obesity (BMI ≥30) by relationship status in breast cancer patients and controls
Source: Own calculation and representation.

The distribution of overweight by education level showed that the higher the education level, the lower the percentage of overweight. The BCP showed 62.4% (n=1332), in figure 4, representing the low education level. Similar findings are presented for the population-based control group with 64.3% (n=2628) on the low level.

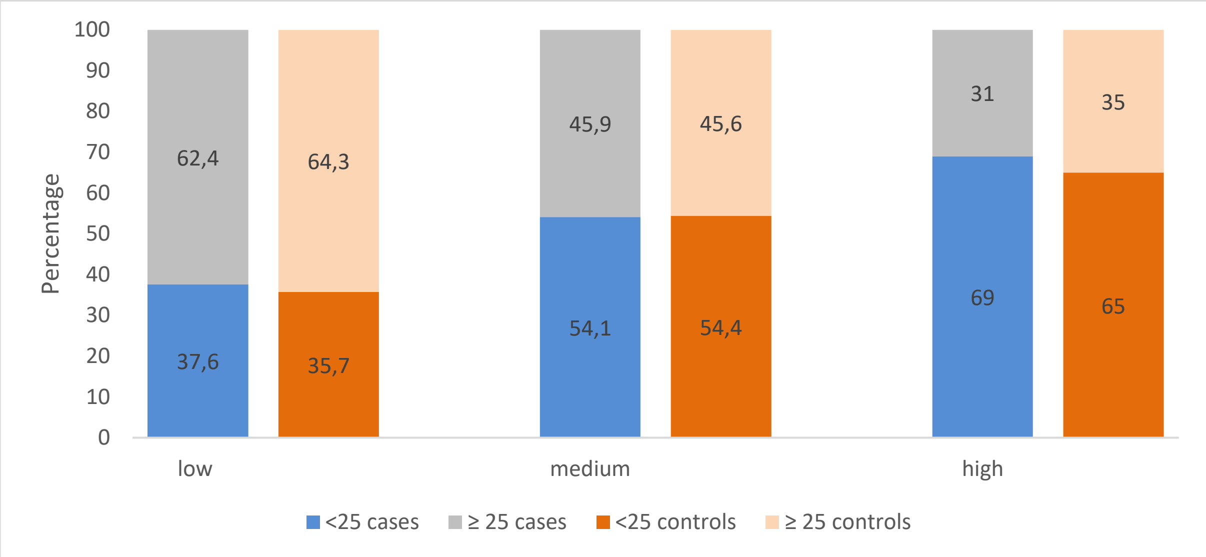

Figure 4: Distribution of overweight (BMI ≥25) by education level in breast cancer patients and controls
Source: Own calculation and representation.

Though the overall percentage of obese people is lower, a similar trend, compared to overweight distribution, was identified. 21% (n=448) of the BCP were obese and classified as having a low education level. The control groups' percentages differed only slightly (low:23.9%; n=978) and followed a similar decline, the higher the education level.

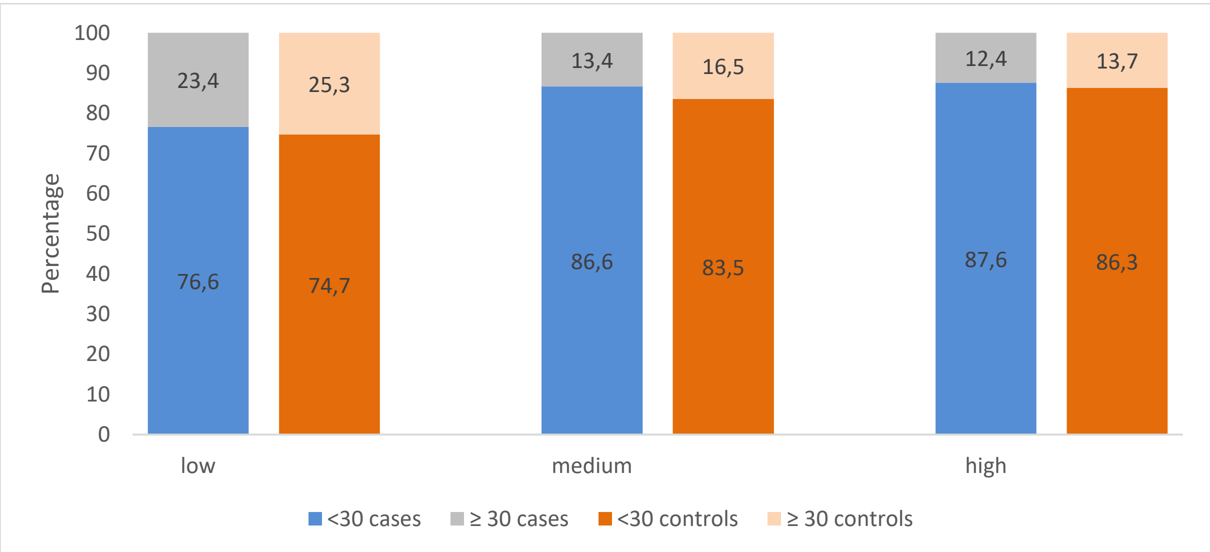

Figure 5: Distribution of obesity (BMI ≥30) by autonomy in occupation level in breast cancer patients and controls
Source: Own calculation and representation.

850 women of the BCP were categorised as overweight and as low autonomy in occupation level (63.3%). The control group presented a marginally higher 66.4% (n=1703) of participants matching the low level. A downwards trend of bodyweight was noticeable, the higher the autonomy in occupation level. As shown in figure 5, 25.3% (n=648) of the low autonomy in occupation controls were categorised as obese, compared to the 23.4% (n=314) of the BCP' same category.

Comparing BCP to the population-based control group, the most striking result of this section was that bar one exception, overweight and obesity presented higher percentages for the control group.

Correlation Analyses. In order to explain the bivariate associations between the independent variables and the covariates, as well as between the individual influencing factors and the dichotomous BMI variables, the respective correlations were calculated depending on the data levels. For the tests using the IVs, selected aspects of SES, marital status, relationship status, education and autonomy in occupation with the dichotomous DVs, overweight and obese the Pearson Chi^2 and Cramer V were calculated. For the tests with the metric covariates, physical activity, age, alcohol consumption and ordinal SES aspects, education and autonomy in occupation, the Spearman's rank correlation and the correlation coefficient was used. To test the relationship between smoking status and alcohol consumption, the Kruskal-Wallis test was performed, and Cohen's d was calculated. The complete results of the correlations, Kruskal-Wallis test and calculated strength of effects between the individual variables, as well as their respective significances, can be found in Appendix C.

Relationships of the independent variables and covariates in the case and control group

Using Spearman's rank correlation, the bivariate association between variables of at least ordinal data level was tested. The education level correlated significantly with the autonomy in occupation level (r_s=0.474; p=<0.001; n=7159) in case of the population-based control group. The result for the BCP presented a slightly lower correlation coefficient (r_s=0.455; p=<0.001; n=3723). According to Cohen, both case and control group showed a moderate effect. The following results applied to case and control group as the findings differed only slightly. A significant negative correlation was found testing education level with physical activity, alcohol consumption with age and physical activity with age. The effect sizes were very weak. Education level and alcohol consumption, as well as autonomy in occupation with alcohol consumption, presented a significant positive correlation with a weak effect size. Level of education with age and autonomy in occupation with age were correlated negatively and significantly with a weak effect size. Both groups presented an insignificant correlation between autonomy in occupation and physical activity (BCP: r_s=-0.124; p=0.073; Controls: r_s=0.004; p=0.763) as well as alcohol consumption and physical activity. For both relationships, the calculated effect size was very weak.

To test the relationship of smoking status with alcohol consumption, the Kruskal-Wallis test was used, to examine if the central tendencies of the groups differ. The significant results for the BCP and population-based control group suggested that the central tendencies were different. The post-hoc test showed between which categories the differences occurred. The complete results can be seen in Appendix C, as well as the calculated effect sizes which presented for both case and control groups very weak and weak results.

The correlation analyses between the IVs and covariates presented very weak, weak and in case of the education and autonomy in occupation analysis, moderate effect sizes, in both case and control group. The results were all significant except for the tests on autonomy in occupation with physical activity and alcohol consumption with physical activity.

Correlation of independent and dependent variables in respect of case and control group

The following results for the overweight DV applied to case and control group as the findings differed only slightly. Marital status with overweight presented a significant association; the calculated Cramer-V suggested a very weak effect size. Education level and autonomy in occupation were both significantly associated with overweight presenting a weak effect size. An insignificant result was calculated for the association of relationship status with overweight. The effect size was very weak.

Changing the DV to obesity presented significant associations with all SES aspects except relationship status in the case group. The control group (X^2=8.5; p=0.004; Phi=0.03) presented a very weak effect size for relationship status with obesity, whereas the BCPs' calculated Phi indicated a weak effect size for marital status with obesity (X^2=11.11; p=<0.09; Phi=0.28). A weak effect size was found for education level and autonomy in occupation level with obesity, respectively.

The correlation analyses revealed weak and very weak associations between the IVs marital status, relationship status, education, autonomy in occupation, and DVs overweight and obesity. All results were significant except the correlation analyses between relationship status and overweight for both BCP and population-based controls and relationship status with obesity in the case group. The complete results can be found in Appendix C.

4.3 Binary logistic regression analysis

In the following chapter, the examination of the statistical assumptions for performing a binary logistic regression is explained. It is followed by a description of the individual steps in the analysis of the models and the presentation of the results.
The purpose of binary logistic regression analysis is to determine the influence of the predictors to the outcome variable, which in this thesis are overweight and obesity.

As explained in section 3.3.3, the possible interactions between each of the four SES aspects were examined, in preparation for building the regression model. The tested interaction terms did not yield significant results, as analyses were performed with only one SES variable at a time. The results of the bivariate analysis, examining the independence of the IVs, DVs and possible confounders, showed no relevant dependencies between the individual influencing factors. Therefore, further testing of interaction in the multivariate analysis can be dispensed with.

To summarise the conditions:

- Binary coded DVs
- Categorical IVs
- IVs not highly correlated with each other

Thus, all requirements for binary logistic regression analysis were met.

Association of SES aspects with overweight

In this section's crude model, the binary logistic regression analysis was performed with overweight as the DV and one IV each. In the adjusted models, the possible confounders age, smoking status, physical activity and alcohol consumption were taken into consideration. The following table 3 shows the crude and adjusted odds ratios of the BCP and the population-based control group, with the respective 95% confidence interval, p-values and sample size.

The results for marital status, in the crude model, showed that the odds of overweight amongst widowed women were 1.43 (CI 1.25-1.64) times higher for the population-based control group, and 1.27 (CI 1.06-1.54) times higher for the BCP, compared to women in the married category. Adjusting the models lowered the odds ratio to 1.3 (CI 1.13-1.5) in the control group and 1.17 (CI 0.97-1.42) for the BCP. The stated results were significant except for the adjusted model of the case group. Being single was associated with lowered odds of overweight compared to married women in both cases and controls.

Evaluating the relationship status results, it was noticeable that the adjusted model showed slightly increased odds of overweight, if the women had no partner compared to the reference group, in both case (1.07 CI 0.92-1.23) and control group (1.02 CI 0.92-1.23). The results were insignificant.

Table 3: Results considering overweight in BCP and controls

Controls		crude model			*adjusted model		
Marital status	**n over-weight**	**OR**	**95%CI**	**p**	**OR**	**95%CI**	**p**
Married	2580	Ref.			Ref.		
single	183	0.69	0.57-0.85	<0.001	0.73	0.59-0.89	0.003
Separated	53	0.94	0.63-1.39	0.75	0.97	0.65-1.44	0.86
Divorced	417	0.8	0.69-0.93	0.003	0.87	0.75-1.01	0.07
Widowed	684	1.43	1.25-1.64	<0.001	1.3	1.13-1.5	<0.001
Relationship status							
partner no	1146	1	0.91-1.1	0.97	1.02	0.92-1.23	0.37
partner yes	2771	Ref.			Ref.		
education							
low	2628	3.34	2.9-3.86	<0.001	2.99	2.59-3.47	<0.001
medium	924	1.56	1.33-1.81	<0.001	1.47	1.26-1.72	<0.001
high	365	Ref.			Ref.		
autonomy in occupation							
low	1703	2.54	2.25-2.88	<0.001	2.27	1.99-2.57	<0.001
medium	1434	1.34	1.19-1.51	<0.001	1.26	1.12-1.43	<0.001
high	780	Ref.					
Cases		**crude model**			***adjusted model**		
Marital status	**n over-weight**	**OR**	**95%CI**	**p**	**OR**	**95%CI**	**p**
married	1294	Ref.			Ref.		
single	104	0.69	0.53-0.91	0.009	0.71	0.54-0.93	0.01
separated	22	0.56	0.33-0.96	0.04	0.62	0.36-1.07	0.09
divorced	226	0.83	0.68-1.01	0.06	0.85	0.69-1.05	0.13
widowed	333	1.27	1.06-1.54	0.01	1.17	0.97-1.42	0.11
Relationship status							
partner no	578	1.04	0.9-1.19	0.63	1.07	0.92-1.23	0.37
partner yes	1401	Ref.			Ref.		
education							
low	1332	3.69	3.02-4.51	<0.001	3.52	2.87-4.32	<0.001
medium	476	1.89	1.52-2.35	<0.001	1.83	1.47-2.28	<0.001
high	171	Ref.			Ref.		
autonomy in occupation							
low	850	2.20	1.85-2.61	<0.001	2.05	1.73-2.45	<0.001
medium	727	1.25	1.07-1.47	0.009	1.20	1.02-1.42	0.03
high	402	Ref.			Ref.		

*Adjusted for age, physical activity, smoking status, alcohol consumption
Source: Own calculation and representation.

Women who were diagnosed with BC and categorised on the low education level had a 3.69 times (CI 3.02-4.51) higher chance of being overweight than BCP on a high education level. The population-based control group's odds of being overweight when categorised as low education level were 3.34 times (CI 2.9-3.86) higher than the women categorised into the high education level. The adjusted models showed slightly decreased odds (BCP 2.99; controls 3.52) compared to the crude model. All results were significant (p <0.001).

Autonomy in occupation showed similar results as the education level variable in a categorical comparison. With significant results in the case and control group, inclusion in the low category in case of the BCP showed a 2.2 times (CI 1.85-2.61) higher chance of being overweight than the high category. The control group's chance was increased by 2.54 (CI 2.25-2.88) when categorised in the low autonomy in occupation level. The adjusted models showed a slight decrease in odds ratios in both case (2.05 CI 1.73-2.45) and control group (2.27 CI 1.99-2.57), compared to the crude models.

Comparing the case and control group with the results of the respective adjusted models showed, that the odds to be overweight, whichever marital status category appurtenant, were slightly higher in the population-based controls (i.e. single: BCP 0.71 CI 0.54-0.93; controls 0.73 CI 0.59-0.89).

Both groups presented insignificant results in the relationship category, with the odds of being overweight at 1.07 (CI 0.92-1.23) in the BCP being slightly higher than the 1.02 (CI 0.92-1.23) of the control group. The odds of being overweight in both low and medium education level were higher for the BCP compared to the education categories of the control group. The results were significant in all categories. For the variable autonomy in occupation, the chance of being overweight in the medium or low category was slightly lower for the BCP than for the controls (i.e. medium: BCP 1.2 CI 1.2-1.42; controls 1.26 CI 1.12-1.43).

Association of SES aspects with obesity

In the following section, the DV was changed to represent the WHO defined cut-off point to obesity. The crude and adjusted models remained otherwise unchanged. Table 4 shows the crude and adjusted odds ratios of the BCP and population-based control group, with the respective 95 % confidence interval, p-values and sample size.

The crude model's odds of obesity when widowed, as a BCP, was 1.36 times (CI 1.08-1.71) higher than for the married women. Adjusting the model with the possible confounders lowered the odds slightly. In both the case and control group, the widowed category presented the only significant association with obesity when compared to the married group.

Table 4: Results considering obesity in BCP and controls

Controls		crude model			*adjusted model		
Marital status	**n obese**	**OR**	**95%CI**	**P**	**OR**	**95%CI**	**P**
married	853	Ref.			Ref.		
single	61	0.81	0.61-1.08	0.15	0.84	0.63-1.12	0.24
separated	21	1.20	0.74-1.96	0.45	1.22	0.75-1.99	0.42
divorced	156	1.02	0.84-1.24	0.82	1.09	0.89-1.31	0.4
widowed	265	1.47	1.26-1.72	<0.001	1.43	1.22-1.68	<0.001
Relationship status							
no	441	0.83	0.73-0.94	0.004	0.83	0.73-0.95	0.006
yes	915	Ref.			Ref.		
education							
low	978	2.87	2.31-3.56	<0.001	2.67	2.14-3.32	<0.001
medium	275	1.43	1.13-1.82	0.003	1.38	1.08-1.76	0.009
high	103	Ref.			Ref.		
autonomy in occupation							
low	648	2.12	1.81-2.5	<0.001	1.95	1.65-2.3	<0.001
medium	463	1.24	1.05-1.46	0.013	1.18	0.99-1.39	0.062
high	245	Ref.			Ref.		
Cases		**crude model**			***adjusted model**		
Marital status	**n obese**	**OR**	**95%CI**	**P**	**OR**	**95%CI**	**P**
married	397	Ref.			Ref.		
single	31	0.78	0.53-1.16	0.21	0.8	0.54-1.19	0.27
separated	7	0.73	0.33-1.61	0.43	0.82	0.36-1.83	0.62
divorced	71	0.92	0.7-1.21	0.56	0.96	0.73-1.27	0.78
widowed	118	1.36	1.08-1.71	0.009	1.35	1.06-1.71	0.02
Relationship status							
partner no	202	0.85	0.71-1.03	0.09	0.84	0.69-1.01	0.07
partner yes	422	Ref.			Ref.		
education							
low	448	3.22	2.31-4.48	<0.001	2.89	2.06-4.05	<0.001
medium	134	1.80	1.25-2.59	0.002	1.69	1.17-2.44	0.005
high	42	Ref.			Ref.		
autonomy in occupation							
low	314	2.16	1.71-2.73	<0.001	1.94	1.52-2.46	<0.001
medium	197	1.09	0.86-1.41	0.46	1.03	0.8-1.32	0.83
high	113	Ref.			Ref.		

*Adjusted for age, physical activity, smoking status, alcohol consumption
Source: Own calculation and representation.

Examining the relationship status's results, the control group presented in both the crude and adjusted model p-values <0.05, with a 0.83 chance (CI 0.73-0.95) of being obese when they had no partner compared to the women who indicated to have a partner. The BCP odds of obesity, having no partner, were 0.84 (CI 0.69-1.01), in the adjusted model, compared to the women who had a partner. Both the crude and adjusted model presented insignificant results.

The calculated findings for the education level categories were statistically significant in both groups. For BCP on the low education level, the odds of obesity were 2.89 times (CI 2.06-4.05) higher than for the BCP on the high education level. Similar results could be seen for the control group, with 2.67 times (CI 2.14-3.32) higher chance of being obese when appurtenant to the low education level, in comparison to the high level. Adjustment of the model lowered the odds ratio in both groups.

Looking at the autonomy in occupation variable, it can be seen that the adjustment in the control group leads to an insignificant result in case of the medium level. The low level and both categories of the crude model show significant results. The odds of being obese for the low autonomy in occupation level was 1.95 times (CI 1.65-2.3) higher, compared to the women categorised on the high level in the control group, the same result was found in the women with breast cancer.
In both the case and control group, the odds ratios were slightly decreased in the adjusted models.

In the direct comparison of the case and control group, it was noticeable that the probabilities of being obese, regardless of marital status category, were slightly lower for the BCP. In case of the relationship status, the BCP had slightly higher odds of being obese though the result presented an insignificant p-value. The categories' results of the education levels were significant for both case and population-based control group. The BCP had higher odds, in both categories, of being obese compared to the control group. The results were non-significant for both groups on the medium autonomy in occupation level. The BCP presented slightly lower odds ratios than the control group.

When comparing the odds ratios of the crude and adjusted models, only minor deviations were found, so the included covariates do not seem to confound the associations. The Log-Likelihood iteration values of the adjusted models decreased. The Omnibus tests presented statistically significant results for all variables in the adjusted models. The proportion of variance of Nagelkerkes pseudo R^2 was calculated, as shown in Appendix C, with variance clarifications like 8.5% - education level (IV) with overweight (DV) - for the population-based control group. According to the classification table, 61.7% of the cases in the adjusted model could be correctly classified with a cut-off point of 0.5. A difference between the crude and adjusted models was detected. The adjusted models were considered to be suitable for the research question of this thesis.

In summary, statistically significant results can be seen in the predictors' education status and autonomy in occupation, both in the crude models and the adjusted models, which show the influence on overweight and obesity, in the respective groups. Relationship status was only associated significantly with obesity in the population-based control group. In the other analyses, there were no statistically significant results for relationship status and the individual marital status categories. Regardless of the marital status categories, results indicated a stronger association with being overweight and obese for the population-based control group. In case of the relationship status, the BCP had higher odds for both examined DVs. The medium and low education level presented higher odds for the BCP. Autonomy in occupation showed higher odds for the population-based control group in both DVs overweight and obesity, compared to the BCP odds.

5. Discussion

This thesis aimed to analyse factors influencing overweight and obesity in women with BC and a population-based control group. The selected SES aspects marital status, relationship status, education level and autonomy in occupation level were considered as possible influencing factors.

The variables used in the analyses explained the presence of overweight and obesity in the case and control group with a variance clarification between 1.7% and 8.5%. In the binary logistic regressions' adjusted models decreasing values in the iteration and statistically significant results in the Omnibus test could be observed.

When looking at the results of the regression analyses, the predictors did influence the odds of being overweight and obese. However, the results were only statistically significant in all categories for the variable education level. As can be seen in tables 3 and 4, statistical significance was otherwise only found in some categories.

The results of this thesis partly concurred with the findings of the literature.

5.1 Methodology discussion

In order to prevent possible distortions of results, the participants with missing values in the analysed variables were removed directly at the beginning of the analysis. As already mentioned at the beginning of this chapter, the results of the iteration and the Omnibus test showed the desired results for a good model quality and fit. However, the low values of variance clarification according to Nagelkerkes pseudo R^2, which ranged between 1.7% and 8.5%, depending on which variables were analysed, made the quality of the model questionable. In general, the analysis through binary logistic regression model was applicable. A higher model quality would be desirable for further investigations (Field, 2013). The critical questioning of the models made sense because of the implicated low model quality, and though there does exist comparable data in the literature, most of the analysed predictors only presented partial statistically significant results. The partly wide confidence intervals in the adjusted models should be considered as well.

5.2 Discussion of the results

In the following section, the influence of the individual SES aspects on overweight and obesity in women with BC and a population-based control group is compared and discussed with the current state of research, based on the results of this work.

The MARIE-study's data provided an overview of the distribution of overweight and obesity for the sample of women with and without breast cancer in the respective study regions. Over half of the population-based control group (54.7%) and BCP (53.2%) were overweight or obese. Out of those percentages, 18.9% of controls and 16.8% of the BCP qualified as obese.

The observed obesity values from the baseline were lower for both groups than the reported figures for adult women (23.9%) in a German health study and higher than those found in France (overweight: 41.4%; obese: 17.6%), except for the BCP (Lampert et al., 2013; Vernay et al., 2009). The WHO published that 40% of the women worldwide were overweight and 15% obese, in 2016 (WHO, 2019d). As mentioned before, the information to calculate the BMI was self-reported by the MARIE-study participants. When comparing the different study results, the time points of data collection should be considered, and the overall differences between the populations in case of the national and international research findings.

Marital status and relationship status. As mentioned earlier, the literature presented contradictory results. Some studies' findings suggested that people who live without a partner, separated, widowed or divorced had a higher chance of being overweight (Sobal et al., 2009; Vernay et al., 2009). Others concluded that a partnership and married status presented higher odds of being overweight (Hilz and Wagner, 2018). Some research suggested to consider changes in marital status over time, e.g. married to widowed or single to married, as significant differences in the odds ratios of being overweight or obese were observed (Sobal et al., 2009; Teachman, 2016).

The analyses of marital status and relationship status with overweight presented in both BCP and population-based control group lower odds to be overweight for the categories single, separated and divorced. Those results concurred with findings of a study researching the relationship of marital status, marital transitions and bodyweight over a time span of 20 years (Teachman, 2016). The widowed category showed in both groups higher odds of being overweight compared to the married women, which coincided with findings by Vernay and colleagues (2009). Both groups had higher odds of being overweight when the women indicated they had no partner compared to the reference category.

Changing the DV to obesity, slight differences between case and control group were observed. The control group presented significantly higher odds of being obese in the widowed category, compared to the married women, which is partly in line with previous results indicating that women who belong to the separated, divorced and widowed category had 1.47 times (CI 1.06-2.06) higher odds to be obese compared to the married category (Vernay et al., 2009).

Comparing the results of the BCP and population-based control group the odds of being overweight were slightly higher in the control group's marital status categories, and the BCP's odds were slightly higher in the relationship status category. As there were mixed and partly statistically insignificant results, the hypotheses set out in chapter 2 which stated that women with or without BC who are not married are more likely to be overweight, and women with or without BC who are not in a relationship are more likely to be overweight, had to be rejected. In reverse, single women were less likely to be overweight. The population-based control group presented higher odds of obesity in the marital status categories compared to the BCP. The BCP had higher odds in the relationship status category. In the case of obesity, statistically significant results were only achieved in the widowed category, which applied to the case and control group. Since the number of participants in the widowed category was distinctly lower than the married category and since the other categories had insignificant results, the hypothesis that women with or without breast cancer who are not married are more likely to be obese must be rejected. The hypothesis that women with or without BC who are not in a relationship are more likely to be obese must be rejected as well because in the control group a significantly lower chance of obesity was found if one had no partner and similar odds with an insignificant result were calculated for the BCP.

The **education level** is an essential aspect of the construction of the SES. In some research, the information is used to categorise people if data like income, social status and class are not available (d'Errico, 2017). Further research has shown that education is a useful indicator to reflect the life-course SES. Both statements work with the basic idea that education is a fairly stable variable that rarely changes throughout life. Compared to occupational variables, for example, which might fluctuate considerably more over time (d'Errico, 2017; Newton et al., 2017; Vernay et al., 2009). Marija et al. (2018) found that women who were categorised into the low education level had 1.48 times (CI 1.3-1.69) higher odds of being overweight than their female counterparts on the high education level. A French research team has found an inverse association between the women's education level and body weight. They concluded that the lower the education level was, the higher the chance of being overweight or obese (Vernay et al., 2009). Those observations were consistent with the thesis's findings. The BCP, for example, presented a more than three times higher chance to be overweight when categorised in the low education group. The population-based control group's women who qualified for the low education category showed a more than two times higher chance to be obese compared to the high education women.

All categories presented statistically significant results. Thus, the hypothesis that women with or without breast cancer who have a low education level are more likely to be overweight was accepted. Due to the distinct findings, the similarly formulated hypothesis of education level with obesity was also accepted.

The **autonomy in occupation** levels are formed by standardised questions about titles of occupation, job descriptions and leadership responsibilities (Hoffmeyer-Zlotnik, 2003; Lampert and Kroll, 2009). Occupational variables are an important indicator of social position. The classification systems are rarely completely identical by definition. As long as those respective differences are considered, however, the findings can be interpreted accordingly. Vernay et al. (2009) found that women who were employees or manual workers had almost two times higher odds of being overweight and obese than women in a management position. A study that used occupational variables to calculate the SES found that a low SES had a negative effect on body weight and thus contributed to poor overall health (Foster et al., 2018).

The results showed an inverse effect, the lower the autonomy in occupation level, the higher the chance of being overweight or obese. The BCP categorised into the low level had two times higher odds to be overweight than their counterparts in the high level. Similar results could be found in the control group, with an almost two times higher chance of being obese, when qualifying for the low level, than the high autonomy in occupation women. The population-based control group presented slightly higher probabilities in all categories. It should be noticed that all categories had statistically significant results, except the case and control group's medium categories in the obese analyses. Therefore, the hypotheses that with low autonomy in occupation level, the odds that women with or without breast cancer are overweight or obese is increased can be assumed.

Analyses with the different SES aspects showed varied results between the variables and within the categories. The strongest significant association with overweight and obesity was found with education in both groups. The odds ratios to be overweight or obese were higher in the case group's education categories. Autonomy in occupation was also significantly associated with overweight and obesity, except in the medium category of the obesity analyses in both case and control group. Previous findings suggest that a low SES, defined partly through education and occupational variables, influences behavioural factors and the bodyweight. Overweight or obesity, in turn, heightens the chance to develop breast cancer (Foster et al., 2018; Marija et al., 2018; WCRF, 2018). The odds ratios for the significant autonomy in occupation categories with overweight and obesity were higher in the control group. As both case and control group had higher odds ratios in one of the aforementioned SES aspects, there was no indication for a general difference between the groups.

The marital status, with its categories married, single, separated, divorced and widowed, presented mostly non-significant results. The category single had a significant inverse association with overweight, for both BCP and population-based control group. Changing to obesity the relationship was non-significant. Widowed women in both groups presented higher odds to be overweight or obese compared to married women. Though the odds ratio showed only a little difference, the BCP's association in the overweight analysis was insignificant. However, it should be taken into account that the control group's sample was larger than the BCP, as discussed in the strengths and limitations section. The same effect should be considered interpreting results of the SES aspect relationship status with obesity, whereas the BCP's result of an inverse association was insignificant and though presenting almost similar odds ratios the controls' results were significant. The analyses' results for relationship status with overweight were non-significant for both case and control group.

5.3 Strengths and Limitations

Comparing the results to the literature was impeded as the SES is often defined and structured differently in existing studies. An index was not created, due to missing income data, for the purpose of this thesis; information on income was not assessed in the MARIE-study. Still, the action to separate the individual SES aspects could even bring advantages in terms of comparability. According to d'Errico (2017), using the separate aspects with a research question centred around the SES could make the individual influences and possible interactions more visible and evident. Still, the comparability was not always given, as there are rarely similar definitions of SES aspects, due to different educational systems or classification systems of autonomy in occupation. Amongst other things, it could be beneficial to include such factors as income, parental or father's occupation and health status to consider predictors that have become known as influential, in future research (d'Errico et al., 2017; Lampert and Kroll, 2013).

The measurements needed to calculate the BMI were self-reported by the participants. For self-reported information of this type, a habit of underreporting (weight) and overreporting (height) is known (Teachman, 2016; Vernay et al., 2009).

Using the baseline data of the MARIE-study, no cause-effect relationships could be investigated due to the cross-sectional design. In order to show the causal relationships between the SES aspects and overweight/ obesity, in women with breast cancer and a population-based control group, further studies would have to be carried out or, remaining with the example of the MARIE-study, the follow-up data will have to be considered and observed over time.

It should be noted that the data used for the analyses represent only part of the German population. In order to obtain representative data for the total population, further investigations with data from other federal states would be necessary. Nevertheless, the baseline data has a large sample size where the controls were randomly selected, and procedures such as age and regional matching were performed to provide adequate representation. During the baseline assessment, a lot of information was collected so that it was possible to consider possible confounders.

Since the population-based control group was matched two to one case, the control group is larger and therefore has more power. The greater power might produce more significant results, whereas a smaller sample might have a non-significant result. Though the results do not have to be wrong, it is essential to take this effect into account and if possible, compare trendsetting ORs. An example of such an effect might be the regression analyses of relationship status with obesity, where the ORs presented similar results, but only the control group's result was significant.

As no published study has researched the associations between aspects of SES with overweight and obesity in a population that comprises both of breast cancer patients and a population-based control group, literature research yielded no previous findings to compare this thesis's results. However, this should not only be recognised as a limitation, since through this thesis, first insights into the topic were gathered.

6. Conclusion

As literature research showed, SES and the possible influence is a largely ignored part in breast cancer research. Research focusing solely on SES and body weight concluded that there is an association between SES and overweight/obesity, as well as connections between SES, behavioural factors and body weight. The WCRF (2018), published that maintaining a healthy weight is one of the main preventive actions for BC. Combining those statements this thesis explored the research question if there is an association between the selected SES aspects marital status, relationship status, education level and autonomy in occupation level with overweight and obesity in breast cancer patients and population-based controls. A low education level and low autonomy in occupation level were significantly associated with overweight and obesity. For marital status and relationship status, no consistent results were found that women with or without breast cancer who are not married or are not in a relationship are more likely to be overweight or obese, though some categories presented significant results. Comparing the results of the BCP and population-based control group, no striking differences were observed.

The identified associations, regardless of case status, suggest socioeconomic inequality at the core of the problem. Preventive measures are necessary to achieve an improvement of the conditions, with a primary focus on reaching people on all SES levels, as previous research found that socioeconomic inequalities influence breast cancer care and survival (Dasgupta et al., 2012; Lundqvist et al. 2016; Riba et al., 2019). Skills and knowledge should be imparted with to influence behavioural factors, i.e. nutrition, physical activity, which are known to be related to body weight (Foster et al., 2018). The attempt to maintain a healthy body weight refers to the WCRF's (2018) main preventive recommendation for BC. Due to the high relevance of breast cancer in society, further research with regard to possible influencing factors would be advisable. Further studies should investigate whether and which factors influence the development of breast cancer. Partial aspects of the socioeconomic status, i.e. income, and other behavioural factors, i.e. nutrition, as well as the general health status were not considered in this work and could offer an approach for further investigations. This thesis' results may serve as a starting point for future research where, in the context of SES aspects and overweight/obesity, the survival of BCP could be focused on.

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Affidavit

I hereby confirm that my thesis is the result of my own work. I did not receive any help or support from commercial consultants. All sources and / or materials applied are listed and specified in the thesis.

Furthermore, I confirm that this thesis has not yet been submitted as part of another examination process neither in identical nor in similar form.

Place, Date Signature

Appendix A: Education and Autonomy in Occupation classification

Table 5: Classification of educational groups

Low education level	- no school leaving certificate + no professional education - basic school + no professional education - basic school + professional education or middle school leaving certificate, but no professional education
Medium education level	- middle school leaving certificate + professional education - high school leaving certificate + professional education
High education level	- Abitur + professional education - Abitur + technical high school degree - Abitur + University degree

Source: Hoffmeyer-Zlotnik,2003; Jöckel et al., 1998

Table 6: Classification of occupational groups

Low	- Unskilled worker - Self-employed with 1 employee or alone - Civil servants in the lower grade - Simple Employee - Agriculturist <10ha - Academically self-employed with 1 employee or alone - farmers with ≥10ha - Civil servants in the medium grade - Employees with difficult tasks according to general in-structions - Semiskilled worker - Academically independent with 1-4 employees - Independent with 1-4 employees
Medium	- Skilled worker - Employees with independent performance with limited responsibility - civil servants high grade - cooperative farmer - Academically independent with 5 and more employees - Self-employed with 5 or more employees
High	- Foreman and group leader - Civil servant higher grade - Employees with extensive management responsibilities - PGH member - Mastercraftsman

*Classified in the table are the occupational groups represented in the MARIE-study data.
Source: Hoffmeyer-Zlotnik, 2003; Jöckel et al., 1998

Appendix B: Analysis Plan

Table 7: Dependence analysis plan

	IV/predictor	DV/Outcome
	tests are run for cases and controls	
Kruskal-Wallis	Smoking status (cat./nom.)	Alcohol consumption (metric)
Spearman rank	education (cat./ord.)	autonomy in occupation (cat./ord.)
	education (cat./ord.)	Alcohol consumption (metric)
	education (cat./ord.)	PA (metric)
	education (cat./ord.)	Age (metric)
	autonomy in occupation (cat./ord.)	Alcohol concumption (metric)
	autonomy in occupation (cat./ord.)	PA (metric)
	autonomy in occupation (cat./ord.)	Age (metric)
	Alcohol consumption (metric)	PA (metric)
	Alcohol consumption (metric)	Age (metric)
	PA (metric)	Age (metric)
PearsonChi2	marital status (cat./nom.)	BMI_overweight (dicho.)
	marital status (cat./nom.)	BMI_obese (dicho.)
	relationship status (cat./nom.)	BMI_overweight (dicho.)
	relationship status (cat./nom.)	BMI_obese (dicho.)
	education (cat./ord.)	BMI_overweight (dicho.)
	education (cat./ord.)	BMI_obese (dicho.)
	autonomy in occupation (cat./ord.)	BMI_overweight (dicho.)
	autonomy in occupation (cat./ord.)	BMI_obese (dicho.)
Binary regr.		
Interaction terms	Education (cat./ord.), autonomy in occupation (cat./ord.)	BMI_overweight (dicho.)
	Education (cat./ord.), autonomy in occupation (cat./ord.)	BMI_obese (dicho.)
	Marital status (cat./nom.), Relationship status (cat./ nom.)	BMI_overweight (dicho.)
	Marital status (cat./nom.), Relationship status (cat./ nom.)	BMI_obese (dicho.)
	Education (cat./ord.), Relationship status (cat./ nom.)	BMI_overweight (dicho.)
	Education (cat./ord.), Relationship status (cat./ nom.)	BMI_obese (dicho.)
	Education (cat./ord.), Marital status (cat./nom.)	BMI_overweight (dicho.)
	Education (cat./ord.), Marital status (cat./nom.)	BMI_obese (dicho.)

	Marital status (cat./nom.), autonomy in occupation (cat./ord.)	BMI_overweight (dicho.)
	Marital status (cat./nom.), autonomy in occupation (cat./ord.)	BMI_obese (dicho.)
	Relationship status (cat./ nom.), autonomy in occupation (cat./ord.)	BMI_overweight (dicho.)
	Relationship status (cat./ nom.), autonomy in occupation (cat./ord.)	BMI_obese (dicho.)
Crude	marital status (cat./nom.)	BMI_overweight (dicho.)
Adj.	marital status (cat./nom.), age (metric), alcohol consumption (metric), PA (metric), Smoking status (cat./nom.)	BMI_overweight (dicho.)
Crude	marital status (cat./nom.)	BMI_obese (dicho.)
Adj.	marital status (cat./nom.), age (metric), alcohol consumption (metric), PA (metric), Smoking status (cat./nom.)	BMI_obese (dicho.)
Crude	Relationship status (cat./nom.)	BMI_overweight (dicho.)
Adj.	Relationship status (cat./nom.), age (metric), alcohol consumption (metric), PA (metric), Smoking status (cat./nom.)	BMI_overweight (dicho.)
Crude	Relationship status (cat./nom.)	BMI_obese (dicho.)
Adj.	Relationship status (cat./nom.), age (metric), alcohol consumption (metric), PA (metric), Smoking status (cat./nom.)	BMI_obese (dicho.)
Crude	education (cat./ord.)	BMI_overweight (dicho.)
Adj.	education (cat./ord.), age (metric), alcohol consumption (metric), PA (metric), Smoking status (cat./nom.)	BMI_overweight (dicho.)
Crude	education (cat./ord.)	BMI_obese (dicho.)
Adj.	education (cat./ord.), age (metric), alcohol consumption (metric), PA (metric), Smoking status (cat./nom.)	BMI_obese (dicho.)
Crude	autonomy in occupation (cat./ord.)	BMI_overweight (dicho.)
Adj.	autonomy in occupation (cat./ord.), age (metric), alcohol consumption (metric), PA (metric), Smoking status (cat./nom.)	BMI_overweight (dicho.)
Crude	autonomy in occupation (cat./ord.)	BMI_obese (dicho.)
Adj.	autonomy in occupation (cat./ord.), age (metric), alcohol consumption (metric), PA (metric), Smoking status (cat./nom.)	BMI_obese (dicho.)

Source: Own representation.

Appendix C: Tables of results

Table 8: Spearman correlation analysis of data level appropriate IVs and covariates

	Controls		Cases	
	rs	**p**	**rs**	**p**
educ/occup	0.474	<0.001	0.455	<0.001
educ/alcohol	0.22	<0.001	0.189	<0.001
educ/PA	-0.056	<0.001	-0.056	0.001
educ/age	-0.169	<0.001	-0.136	<0.001
occup/alcohol	0.17	<0.001	0.194	<0.001
occup/age	-0.177	<0.001	-0.124	<0.001
occup/PA	0.004	0.763	-0.029	0.073
alcohol/age	-0.088	<0.001	-0.094	<0.001
alcohol/PA	-0.022	0.062	-0.029	0.081
PA/age	-0.043	<0.001	-0.04	0.014

p=significance, rs=Correlation Coefficient, PA=physical activity; educ= education level; occup=Autonomy in occupation level
Source: Own calculation and representation.

Table 9: Pearson Chi2 correlation analysis of IVs and DVs

	overweight			obese		
Controls	**X^2**	**V/Phi**	**p**	**X^2**	**V/Phi**	**p**
Marital status	56.16	0.09	<0.001	28.33	0.06	<0.001
Relationship status	0.002	0.001	0.97	8.5	0.03	0.004
education	383.39	0.23	<0.001	160.18	0.15	<0.001
Autonomy in occupation	244.04	0.19	<0.001	109.59	0.12	<0.001
Cases						
Marital status	23.9	0.08	<0.001	11.11	0.06	0.03
Relationship status	0.23	0.008	0.63	2.88	0.28	0.09
education	203.29	0.23	<0.001	71.22	0.14	<0.001
Autonomy in occupation	94.19	0.16	<0.001	66.7	0.13	<0.001

X^2= Chi2; V= Cramer-V; p=significance.
Source: Own calculation and representation.

Table 10: Relationship of smoking status by alcohol consumption

	p	df	X^2
controls	<0.001	2	139.63
cases	<0.001	2	74.37

p=significance; df=Degree of freedom; X^2=Chi2.
Source: Own calculation and representation.

controls	p	n	z	d
non-smoker/current	<0.001	5081	-6.875	-0.09
non-smoker/ex-smoker	<0.001	5765	-11.285	-0.14
current/ex-smoker	0.021	3472	2.698	-0.04
cases				
non-smoker/current	<0.001	2697	-5.738	-0.11
non-smoker/ex-smoker	<0.001	2996	-7.877	-0.14
current/ex-smoker	0.789	1753		

P=significance; n=sample; z=z value; d=effect size.
Source: Own calculation and representation.

Table 11: Model fit of the adjusted model

	Overweight			**Obese**		
	Omnibus	p	R^2	Omnibus	p	R^2
Controls						
marital status	X^2=194.99	<0.001	0.036	X^2=92.34	<0.001	0.02
Relationship st	X^2=165.56	<0.001	0.031	X^2=78.33	<0.001	0.018
Education	X^2=468.07	<0.001	0.085	X^2=209.66	<0.001	0.046
Autonomy i occ	X^2=347.59	<0.001	0.063	X^2=154.74	<0.001	0.034
Cases						
marital status	X^2=61.5	<0.001	0.02	X^2=71.68	<0.001	0.03
Relationship st.	X^2=47.23	<0.001	0.017	X^2=66.58	<0.001	0.030
Education	X^2=230.11	<0.001	0.08	X^2=123.24	<0.001	0.055
Autonomy i occ	X^2=124.57	<0.001	0.044	X^2=113.14	<0.001	0.05

X^2=Chi2; p= significance; R^2= Nagelkerkes pseudo R^2
Source: Own calculation and representation.