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Do health-related factors predict major depression? A longitudinal epidemiologic study

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Major depressive disorder (MDD) is a leading cause of global disease burden. Hence, examining the role of risk and protective factors for MDD is an important target in psychological research. Various studies showed that obesity, smoking, and alcohol consumption are related to depressive symptoms. In contrast, physical activity has been found to be a protective factor. The present population-based study tested whether these health-related factors are prospectively associated with incidence of MDD. Data were taken from the Dresden Predictor Study, which was designed to investigate risk and protective factors of mental health in young women. It included two assessments approximately 17 months apart. Results of single logistic regression analyses showed that being overweight, being a smoker, and being in a high-risk drinking group at baseline were predictive of developing MDD at follow-up. Engaging in regular physical activity and having good physical health were found to be protective factors of MDD. However, being in a medium-risk drinking group was not predictive of incidence of MDD, and irregular physical activity was not a protective factor. This is the first prospective, longitudinal study to show that obesity, smoking, and high-risk drinking are predictive of new onsets of MDD and that physical health is a protective factor. These data provide promising avenues for future research.

KEYWORDS

major depressive disorder (MDD), overweight, physical activity, protective factors, risk factors, smoking

1 | INTRODUCTION

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013), a major depressive disorder (MDD) is characterized by two main symptoms: a pervasive and persistent depressed mood state and a loss of interest or pleasure in enjoyable activities. MDD can be long-lasting and recurrent and can cause great distress and significant functional impairment. The enormous costs of health care (World Health Organization, WHO, 2004, 2008, 2017) and massive individual impact, in the form of suffering and disability, make it imperative to understand the pre-disease pathways leading to MDD. Elucidating risk and protective factors of MDD is an important line of research. The promotion of a healthy and active lifestyle has become an important priority for many modern societies. Thus, people have been encouraged to lose weight, stop smoking, decrease alcohol intake, and increase physical activity. However, in order to fully understand the potential role of obesity, smoking, alcohol consumption, and physical activity in the onset of MDD and whether prevention programs targeting these behaviours may be effective for individuals' mental and physical health, studies are needed that examine whether engaging in these behaviours indeed increases or decreases the risk of MDD.

In young women, obesity is related to increased rates of mental disorders, especially anxiety disorders (Becker, Margraf, Türke, Soeder, & Neumer, 2001). The increase in obesity, defined as a body mass index (BMI) of 30 kg/m^2 or greater, is now a global trend (Kim & Popkin, 2006). Hence, research has started to examine its links to other mental disorders as well, including depression (for a review and meta-analysis, see L. de Wit et al., 2010). To illustrate, a study examining a nationally representative sample in New Zealand found that obesity was significantly associated with various types of anxiety and mood disorders, including MDD (Scott, McGee, Wells, & Oakley Browne, 2008). Two North American surveys provided evidence that further specified the association between obesity and MDD. That is, obesity was related to depressive symptoms in women but not in men (Carpenter, Hasin, Allison, & Faith, 2000; Onyike, Crum, Lee, Lyketsos,

& Eaton, 2003). Studies examining incidence of MDD found that obesity assessed at baseline was a risk factor for developing MDD 5 years later, even after controlling for depressive symptoms at baseline and other covariates (Roberts, Deleger, Strawbridge, & Kaplan, 2003). Further, Carpenter et al. (2000) found that obesity was associated with an increased risk of MDD and suicidal ideation among women but not men.

Other important and well-studied risk factors are cigarette smoking and alcohol consumption. Regarding cigarette smoking, there are numerous studies showing that there is a strong association between cigarette smoking and depression, that is, the higher levels of smoking and the higher levels of depressive symptoms. This association is independent of the administered measurement scales and age, with results replicated in adolescent (Fergusson, Lynskey, & Horwood, 1996; Goodman & Capitman, 2000; Patton et al., 2000), adult (Breslau, Kilbey, & Andreski, 1991; Ismail, Sloggett, & De Stavola, 2000; Jorm et al., 1999), and older adult samples (Cervilla, Prince, Joels, Russ, & Lovestone, 2004; Ismail et al., 2000; Lam et al., 2004). Regarding the prediction of onset of MDD, a Norwegian longitudinal cohort study found that heavy smokers had a four times higher risk of developing MDD as compared to never smokers (Klungsøyr, Nygård, Sørensen, & Sandanger, 2006). Further, Khaled et al. (2012) found that current heavy smoking predicted incidence of MDD, even after adjustment for age, sex, and stress (for similar findings, see Flensborg-Madsen Trine et al., 2011; Johnson, Rhee, Chase, & Breslau, 2004; Mendelsohn, 2012; Ragg, Gordon, Ahmed, & Allan, 2013; Windle & Windle, 2001). Findings are similar for alcohol consumption. That is, several large scale, cross-sectional surveys based on community samples have found a positive association between alcohol abuse/dependence and MDD (e.g., Fergusson, Boden, & Horwood, 2009, Gilman & Abraham, 2001; Grant & Harford, 1995; Hasin Goodwin, Stinson, & Grant, 2005; and see for a meta-analysis, Conner, Pinquart, & Gamble, 2009). To illustrate, in Helzer and Pryzbeck's (1988) first wave report of the Epidemiologic Catchment Area, results showed that the odds of meeting criteria for MDD were 1.8 times higher for individuals with alcohol dependence compared with individuals without an alcoholic dependence. Results further showed that the risk of developing MDD was higher among female as compared to male alcoholics. A similar pattern was found in the National Comorbidity Survey, which is a nationally representative survey of 8,098 participants assessing the presence of mental disorders. Here, National Comorbidity Survey data indicated a twofold increased risk for MDD among participants with alcohol dependence (Kessler et al., 1994, 1996; and see also Kessler et al., 1997).

Besides investigating the role of risk factors, research also focused on identifying protective factors for MDD. Here, physical activity is a prominent candidate. Various studies showed that physical activity is associated with mental health. For example, a cross-sectional and prospective-longitudinal epidemiological study in Germany found that regular physical activity was associated with beneficial effects on mental health (Ströhle et al., 2007). Regarding the association between MDD and physical activity, there is empirical evidence showing that the risk for depression is significantly higher in physically inactive as compared to physically active individuals (e.g., Im, Ham, Chee, & Chee, 2015; McKercher et al., 2013; Weyerer, 1992). To illustrate, results of the Aerobics Center Longitudinal Study by Galper, Trivedi, Barlow, Dunn, and Kampert (2006), a national cohort study of 5,451 men and 1,277 women (age: 20–88) across the United States, found that physically inactive men and women were found to be more severely depressed than their active counterparts. Furthermore, there was a dose–response association, in such that those classified as insufficiently active had significantly more depressive symptoms than those classified as sufficiently active. Further, Mikkelsen et al. (2010) showed that compared to women with a high physical activity level, women with a moderate level of physical activity had a risk ratio of 1.07 for developing MDD, and women with a low level of physical activity had a risk ratio of 1.80.

Key Practitioner Message

- Being overweight, being a smoker, and belonging to a high-risk drinking group predicted new onsets of major depressive disorder in young women.
- Engaging in regular physical activity and having good physical health were found to be protective factors of major depressive disorder in young women.
- A healthy and active lifestyle is crucial from both a physical and mental health perspective.

To conclude, there is a large body of evidence supporting the important role of health-related risk and protective factors in the context of MDD. Despite the importance of these findings, however, there are a number of limitations to the existing research. First, many studies used levels of depressive symptomatology as outcome variables. Although such research is important, these data merely show that the investigated health-related factors are a correlate of depression. Hence, what is missing is evidence showing that health-related factors are also predictive of new onsets of MDD, that is, evidence showing that such factors are indeed risk and protective factors (for a detailed overview of how to structurally examine a potential causal risk factor in psychopathology, see Kraemer et al., 1997). Second, because of the correlational design of most previous studies, the direction of the association remains unclear. To illustrate, if a positive association between levels of alcohol consumption and depression has been found, it is unclear whether high levels of alcohol consumption is a risk factor for MDD or MDD is a risk factor for high levels of alcohol consumption. Third, there are only a few longitudinal and population-based studies. Fourth, previous studies investigated the predictive validity of obesity, smoking, alcohol consumption, and levels of physical activity in isolation. Although these studies provided valuable insights, their conclusions are limited as only one potential risk was investigated. However, most risk factors are highly correlated. As such, it is important to understand which of these factors remain significant when combined into one regression in order to better understand their unique predictive validity in the broader health context. This is important from a theoretical perspective (e.g., to refine models of psychopathology) but also from a clinically applied perspective (e.g., when developing prevention programs). Therefore, research is needed that combines them and investigates their predictive validity within one sample.

1.1 | The present study

This study employed a longitudinal prospective design to test the predictive validity of four health-related factors for new onsets of MDD: obesity, smoking, alcohol consumption, and levels of physical activity. An epidemiologic, population-based sample of young German women completed an assessment on two occasions. Each assessment included a DSM diagnostic interview and a number of health-related self-report measures. We predicted that baseline levels of obesity, cigarette smoking, and alcohol consumption would predict new onsets of MDD at follow-up. However, physical activity was expected to be a protective factor of MDD.

2 | METHOD

2.1 | Procedure and sample

Data were collected within the larger Dresden Predictor Study (DPS; for more details see Trumpf et al., 2010). Thus, the present analyses should be considered secondary analyses. The DPS is a prospective epidemiological study that was conducted in the former East Germany, designed to investigate risk and protective factors of mental disorders in young women according to DSM-IV criteria (DSM-IV, American Psychiatric Association, 1994). It included a broad range of questionnaires to record various psychological, cognitive-behavioural, and socio-environmental factors that are assumed to be involved in anxiety disorders and depression. These factors included protective factors, coping behaviours, cognitive factors, critical life events and stress, and general health behaviours.

The DPS used an unweighted random sampling procedure: In April 1996, the baseline sample with 9,000 addresses was randomly drawn from the representative registers of the government registry office in Dresden. The selected women were contacted by post, which included information about the study and its aims, a data privacy statement, and a stamped postcard to be able to make a direct appointment. Further, it was explained that additional contact requests would follow (i.e., in writing, by telephone, or in person) and that participating in the study was voluntary. For the recruitment, all three contact options were combined in order to achieve the highest possible number of participants. Participants were contacted by project staff, by the interviewers directly, or by specially trained "contactors." All contactors were thoroughly informed about the study, the data protection guidelines, and trained in conversation skills.

The study's selection criteria included being a German female and being aged between 18 and 25 years at the time of the baseline assessment. Following these criteria, 5,203 women were located and considered as eligible for the study. The interview could take place at the Dresden University of Technology (TU Dresden), at the participant's home, or at a third location. For the follow-up study, only women who had participated in the baseline assessment and who also had agreed to participate in the follow-up study were contacted. Again, they were contacted in writing, by phone, or in person. There was no compensation offered for the baseline assessment. For the follow-up assessment, however, sponsors were found, and each participant was offered a small gift package.

The baseline assessment was joined by 3,065 (58.9%) women and was conducted from July 1996 to September 1997. Of these, 1,881 completed both the diagnostic interview and the questionnaires. For the follow-up assessment, 2,788 women agreed to participate, and 2,118 (76.0%) of them completed it. At follow-up assessment, 1,482 women finished both the diagnostic interview and the questionnaires. The follow-up was conducted approximately 17 months after the baseline assessment (range: 6–30 months), that is, from December 1997 to February 1999. A more detailed description of the study design, including more information about the sampling methods, the representativeness of the sample, and analyses of nonresponse bias and dropouts, is reported elsewhere (Trumpf et al., 2010). A detailed overview of the initial prevalence and incidence rates of DSM-IV disorders can be found in Becker et al. (2000).

The DPS study was first approved by the Saxon Data Security Office ("Sächsische Datenschutzbeauftragte"), which is one of the highest data protection authorities in Germany, and was then under further ethical control by the internal review board of the TU Dresden.

2.2 | Diagnostic assessment

At both assessments, a trained interviewer administered the "Diagnostisches Interview bei psychischen Störungen—Forschungsversion" (Margraf, Schneider, Soeder, & Becker, 1996; translation: Diagnostic Interview for Mental Disorders—Research Version) individually to each participant. The Diagnostisches Interview bei psychischen Störungen—Forschungsversion assesses DSM-IV Axis I disorders. Additionally, participants completed a battery of self-report questionnaires that provided detailed information about potential predictors of disorders and a comprehensive dimensional assessment of psychopathology. At baseline, the interview provided 7 days point and lifetime prevalence diagnoses. At follow-up, the interview provided 7 days point and period (i.e., from the interval between the two investigations) prevalence diagnoses.

Out of the 1,482 women who finished both diagnostic interviews, 1,209 (81.58%) participants had never met lifetime criteria for any affective disorder at baseline. Of them, 1,118 women did not meet lifetime criteria for any affective disorder at follow-up. Hence, this group served as control group for this study. Of main interest for this study, however, was MDD incidence rates during the 17-month interval. Here, results showed that 78 (6.45%) women developed MDD during the 17-month follow-up period. Of the remaining 13 women, five (0.41%) women developed a bipolar I disorder, five (0.41%) women met bipolar II disorder, and three (0.25%) women suffered from a Cyclothyme disorder. However, given the small number, these participants were not included in any statistical analyses.

3 | HEALTH-RELATED FACTORS

3.1 | Risk factors

BMI was calculated based on self-reported weight and height, that is, the weight in kilograms divided by the square of the height in metres (kg/m^2). Because BMI, when used as an interval variable, was not significantly associated with the incidence of MDD ($r = .041$, $p = .156$), which

is a prerequisite for logistic models, we transformed this predictor into a categorical variable (see also results by L. M. de Wit, van Straten, van Herten, Penninx, & Cuijpers, 2009, who found a U-shaped association in this context). Hence, following recommendations of the WHO (2000), BMI was classified into four categories: 1 = normal weight ($18.5 \leq BMI < 25\ kg/m^2$), 2 = underweight ($BMI < 18.50\ kg/m^2$), 3 = overweight ($25 \leq BMI < 30\ kg/m^2$), and 4 = obese ($BMI \geq 30\ kg/m^2$). The first category "normal weight" served as the reference category.

Smoking was assessed by three items, assessing whether participants currently smoke (response options were 1 = "Yes" or 0 = "No"), how many cigarettes they smoke during an average day, and participants' age when they started smoking. However, the latter two variables showed no significant correlation with the incidence of MDD (number smoked cigarettes: $r = -.001$, $p = .91$; age: $r = -.007$, $p = .99$). Hence, they were not included in the analyses.

Alcohol consumption was assessed with a questionnaire developed for a Swiss health survey (Frick, Rehm, Thien, & Spuhler, 1996). It included questions assessing participants' drinking pattern in the last week and last 12 months, respectively. Questions about the consumption of beer, wine, and spirits were converted into a variable called "risk level alcohol consumption," reflecting levels of alcohol consumption in grams per day. According to recommendations of the National Health and Medical Research Council (NHMRC, 2000) and consistent with guidelines for responsible drinking provided by WHO (2004), three categories were created for risk level: 1 = low-risk drinking (up to 20 g alcohol/day); 2 = medium-risk drinking (20–40 g alcohol/day); 3 = high-risk drinking (over 40 g alcohol/day). Moreover, there were five questions about alcohol-related problems, assessing the individual's impairment related to drinking, losing control, and social implications of drinking abusively. (Item 1: "Have you ever considered drinking less alcohol?", Item 2: "Did you ever have the feeling that alcohol is not good for you?", Item 3: "Do you sometimes drink more than you wanted?", Item 4: "Have you had ever any trouble with other people because of your alcohol consumption?", and Item 5: "Has anyone ever told you to drink less?"). Item 1 and 4 have dichotomous answer options: 1 = "Yes" or 0 = "No". The other three items have three answer options, and they were coded as 1 = "Yes, sometimes"/"Yes, but rarely" and 0 = "No". A sum score of these five items named alcohol-related problems was computed, with higher values indicating more drinking problems.

3.2 | Protective factors

Physical activity was assessed with the following question: "How frequently do you engage in physical activity?" There were five response options: 1 = several times a week, 2 = once a week, 3 = 1–3 times a month, 4 = less than once a month, or 5 = never. As a rule of thumb for logistic regressions and in order to have sufficient statistical power for the analysis, a minimum of 10, but if possible, a minimum of 20 events is needed per predictor variable (see, e.g., Harrell, Lee, & Mark, 1996). However, this factor did not meet this criterion (11 events for "several times a week", 19 events for "once a week", 14 events for "1–3 times a week", 20 events for "less than once a month", and 7 events for "never"). Hence, the response options were grouped into three categories: (a) "regular" = several times a week, (b) "non-regular" = once a week or 1–3 times a month, and (c) "no" = less than once a month or never. The first category "regular" served as the reference category.

Subjective good physical health was assessed with one item: "My physical health is very good". Participants were required to indicate how they agree with this question by using four response options: 0 ("not true"), 1 ("rather not true"), 2 ("rather true"), and 3 ("true"). Because some response options had a low number of events per cell (3 events for "not true", 11 events for "rather not true", 36 events for "rather true", and 21 events for "true"), the four categories were grouped into two categories and rated as 1 = true (including "rather true" and "true") and 0 = not true (including "rather not true" and "not true").

3.3 | Analytic approach

To examine whether the risk and protective factors predicted new onset of MDD, we first conducted six separate logistic regressions. Each regression included one predictor variable: BMI, being a smoker, risk level alcohol consumption, alcohol-related problems, levels of physical activity, and good subjective physical health. Second, a multiple logistic regression analysis was used to examine the variables' relative contribution to the prediction of the incidence of MDD. The multiple logistic regression included all significant predictors of the previous separate logistic regressions. The strength of association between the predictor variables and incidence is represented by the odds ratio (OR). That is, the OR indicates how strongly the presence or absence of a certain factor is associated with the presence or absence of MDD. An OR of 1.0 indicates no association between the predictor and the incidence of MDD. For continuous predictors, the OR indicates by which factor the odds increases if the predictor value increases by exactly one unit.

In clinical and population-based health research, an important issue when testing a clinical prediction model is to assess how well it performs in individuals who are similar to those used for model development. Furthermore, it is well established that the number of events per variable (EPV) is the key in prediction models for binary outcomes. Researchers suggested that EPV should be at least 10 to provide an adequate predictive model (Peduzzi, Concato, Kemper, Holford, & Feinstein, 1996). Researchers also found that apparent performance, which is derived from the entire original sample, is too optimistic for internal validation of regression-based prediction models (Austin & Steyerberg, 2014). Here, bootstrapping is recommended for estimation of internal validity of a predictive logistic regression model (Austin & Steyerberg, 2014; Steyerberg et al., 2001). In our multiple logistic regressions, the EPV values were not greater than 10. This indicates that our model may not be an adequate predictive model if only using the present data. Therefore, we used 2,000 bootstrap samples in our study to provide bootstrap-corrected 95% confidence intervals for OR to quantify the uncertainties in the inferences. All analyses were performed using IBM SPSS Statistics 22.0.

4 | RESULTS

4.1 | Descriptive statistics

Table 1a summarizes the sample's sociodemographic data at baseline. Table 1b gives an overview of the descriptive data of the two groups,

TABLE 1A Sociodemographic data at baseline (N = 1,196)

	%
Marital status	
Single	96.2
Married (living with a partner)	3.4
Married (not living with a partner)	0.2
Widowed	0.2
Having a romantic partner	63.5
Highest educational level	
No degree	4.3
Mandatory basic	2.3
Intermediate[a]	28.6
Highest[b]	64.8
Socio-economic status[c]	
Low[d]	27.2
Middle[e]	64.0
High[f]	8.5
	Mean (*SD*)
Age	21.03 (1.73)

Note. *SD* = standard deviation.

[a]This includes two types of secondary schools in Germany with lower entry requirements that do not qualify to study at a university.

[b]This includes a type of secondary school with the highest entry requirements that does qualify to study at a university (achieved degree comparable to "A level").

[c]Categorization according to current vocational qualification of participant and participant's parents.

[d]This category included, for example, being unemployed, only doing voluntary work, being a housewife/househusband, being employed in manual/unskilled labour, and being an apprentice.

[e]This category included, for example, being employed in skilled/qualified labour.

[f]This category included, for example, working in academia and being employed with a leading function.

TABLE 1B Descriptive statistics of health-related factors at baseline for the two groups, that is, incidence of MDD yes/no

	Incidence of MDD	
	No	Yes
Body mass index**		
<18.5 (n = 172)	160 (93.0%)	12 (7.0%)
≥18.5 and <25 (n = 917)	864 (94.2%)	53 (5.8%)
≥25 and <30 (n = 85)	72 (84.7%)	13 (15.3%)
≥30 (n = 13)	13 (100.0%)	0 (0.0%)
Smoker*		
Yes (n = 273)	247 (90.5%)	26 (9.5%)
No (n = 884)	836 (94.6%)	48 (5.4%)
Risk level alcohol consumption*		
Low risk (n = 1080)	1,016 (94.1%)	64 (5.9%)
Medium risk (n = 49)	44 (89.8%)	5 (10.2%)
High risk (n = 16)	13 (81.3%)	3 (18.7%)
Alcohol-related problems		
Mean (*SD*)	0.82 (1.04)	0.89 (0.94)
Physical activity*		
Regular (n = 299)	288 (96.3%)	11 (3.7%)
Non-regular (n = 541)	508 (93.9%)	33 (6.1%)
No (n = 291)	264 (90.7%)	27 (9.3%)
Good physical health**		
True (n = 1,039)	982 (94.5%)	57 (5.5%)
Not true (n = 93)	79 (84.9%)	14 (15.1%)

Note. N varies because of missing data for certain measures. Chi-square tests were conducted for categorical variables, and a t test was conducted for alcohol-related problems. *SD* = standard deviation; MDD = major depressive disorder.

*p < .05.

**p < .01.

***p < .001.

that is, with and without MDD, at follow-up. The descriptive data are presented for all health-related factors, that is, for each category level per factor. Results showed that the highest incidence (18.7%) was in the high-risk drinking group. The second highest incidence was found in the overweight group (15.3%). Furthermore, we also compared incidence rates within categories. MDD was more prevalent among women who did not have a good physical health, compared to those having a good subjective physical health. Smokers were more likely to suffer from MDD than those who did not smoke. Women with harmful drinking patterns (over 40 g alcohol/day) had a higher incidence of MDD than those who drank up to 40 g alcohol/day. Finally, women who developed MDD had higher scores of alcohol-related problems than those women who did not develop MDD.

4.2 | Logistic regressions

Before we conducted the single and multiple regression analyses, we inspected the data per risk and protective factor. The 13 obese participants with a BMI greater than 30 were all in the group that did not develop MDD. Hence, they were not suitable to be included in the logistic regression and thus excluded. We deliberately selected the present sample's age range because early adulthood is the peak period for the first onset of many mental disorders, especially anxiety disorders and depression (e.g., Kessler, Berglund, Demler, Jin, & Walters, 2005). Hence, we did not include age as a predictor in any of the regression analyses. This was further supported by the finding that the two groups did not differ significantly in age (i.e., no incidence of MDD vs. incidence of MDD: p = .975). In addition, the two groups did not differ regarding the duration of the follow-up assessment period (p = .617). As such, this was also not included as control variable.

4.2.1 | Simple logistic regression

The separate simple logistic regressions (Table 2) revealed the following results:

BMI, being a smoker, and a risky level of alcohol consumption were significant risk factors for new onsets of MDD. Specifically, women who were overweight, smoked, or were in a high-risk drinking group (over 40 g alcohol/day) at baseline were more likely to develop MDD at follow-up. At the same time, women who engaged in regular physical activity or women who had a good subjective physical health

TABLE 2 Results from separate and multiple logistic regression analyses predicting incidence of MDD over 17 months

	Separate logistic regression			Multiple logistic regression		
	OR	95% CI	Bootstrap 95% CI	OR	95% CI	Bootstrap 95% CI
Body mass index						
Underweight versus normal	1.22	[.64, 2.34]	[.54, 2.17]	1.02	[.50, 2.10]	[.42, 1.98]
Overweight versus normal	2.94**	[1.53, 5.65]	[1.43, 5.45]	2.38*	[1.14, 4.98]	[1.11, 4.44]
Smoker						
Yes versus no	1.83*	[1.11, 3.02]	[1.11, 2.96]	1.55	[.90, 2.66]	[.89, 2.62]
Risk level alcohol consumption						
Medium risk versus low risk	1.80	[.69, 4.71]	[.36, 4.10]	1.50	[.56, 4.05]	[.45, 3.16]
High risk versus low risk	3.66*	[1.02, 13.18]	[9.66E-09, 11.87]	1.73	[.37, 8.18]	[6.92E-09, 5.15]
Alcohol-related problems	1.07	[.86, 1.33]	[.87, 1.29]			
Physical activity						
Regular versus no	.37**	[.18, .77]	[.16, .75]	.48	[.23, 1.01]	[.20, .94]
Non-regular versus no	.64	[.37, 1.08]	[.38, 1.12]	.74	[.42, 1.28]	[.42, 1.32]
Good physical health						
True versus not true	.33**	[.18, 0.61]	[.18, .69]	.35**	[.18, .69]	[.19, .76]

Note. MDD = major depressive disorder; *SD* = standard deviation; OR = odds ratio; CI = confidence intervals.

*$p < .05$.

**$p < .01$.

***$p < .001$.

at baseline were less likely to develop MDD than those without these protective factors. Having alcohol-related problems, however, was not a significant predictor of MDD. The bootstrap-corrected confidence intervals were only slightly different from the confidence intervals of the logistic regressions, because for these single models, EPV was ≥10 (i.e., the statistical power was sufficient). However, for the high-risk drinking group, the bootstrap-corrected confidence intervals were much different from the apparent confidence intervals as the EPV for this predictor was EPV = 3 (see also Austin & Steyerberg, 2014).

4.2.2 | Multiple logistic regression

A multiple logistic regression including all significant predictors was calculated to examine their combined contributions to the prediction of MDD. Results showed that BMI and having a good subjective physical health were significant, independent predictors of the incidence of MDD. However, when using bootstrap-corrected confidence intervals, physical activity was an additional significant predictor.

5 | DISCUSSION

The aim of this study was to investigate whether health-related factors, that is, obesity indexed by BMI, smoking, levels of alcohol consumption, and physical exercise, predicted new onsets of MDD. For this purpose, a longitudinal epidemiologic study was conducted among young German women. Results of the single logistic regressions showed that BMI (the overweight group), being a smoker, risk level of alcohol consumption (the high-risk drinking group), physical activity (the regular group), and having a good subjective physical health were predictive, health-related factors regarding new onsets of MDD. These results remained stable after bootstrapping. The multiple logistic regression including all significant health-related factors revealed the following: BMI (the overweight group) and having a good physical health were significant predictors. However, after bootstrapping, also the factor physical activity was a significant predictor (the regular group).

To the best of our knowledge, this study is the first to test the combined predictive validity of five well-established health-related factors in MDD. Unlike previous studies that investigated their role as a correlate of MDD, we investigated their predictive validity of *new onsets* of MDD. This is an important advantage as most previous studies used correlational designs, within the area of MDD but also in the general emotional psychopathology area (for exceptions, see, e.g., Woud, Zhang, Becker, McNally, & Margraf, 2014; Woud, Zhang, Becker, Zlumozica, & Margraf, 2016). Further, we investigated these factors in combination with each other, which is, from a broader health context, a much more ecologically valid approach. When comparing the results of our multiple regression post-bootstrapping to those studies that did test incidence of MDD, one can generally conclude that we replicated these findings, that is, obesity is a risk factor for MDD, and good physical health and physical activity are protective factors of MDD. An interesting issue, however, arises when considering the fact that only these three factors are significant in the multiple regression. The most parsimonious explanation is that there is shared variance among the included predictors, in turn suggesting that there is some overlap in the nature of how they are associated with MDD. Good subjective physical health is a good example here: That is, those women who experience a good subjective physical health are probably also those who neither smoke nor drink much. Hence, this comorbidity makes it difficult for the latter factors to still have unique predictive power when entered to the multiple regression. When interpreting results of the multiple regression, however, this does not mean that the non-significant predictors such as being a smoker and engaging in risky levels of alcohol consumption should be neglected as risk

factors. First, smoking was a significant predictor in the single logistic regression. Second, other studies found them to be significant risk factors for MDD, even when they controlled for other relevant variables (e.g., Khaled et al., 2012). Third, these factors clearly represent unhealthy behaviours. Again, the role of comorbidity could explain our findings for these two factors. That is, smoking and drinking are unlikely to have unique predictive value other than that they share with, for example, good physical health. Comparing our OR to those of other studies is quite a difficult endeavour as there are various factors that need to be considered here, for example, how many predictors were entered into the regression, the sample's size and characteristics, which measures were used. Hence, in order to obtain a full and in-depth understanding of this matter, systematic comparisons against meta-analyses would be needed, per factor. When comparing the ORs within our study, that is, between the single and multiple logistic regressions of those predictors that remained significant, however, we can conclude that the ORs remained rather stable. For BMI, the risk of developing MDD remained twice to almost triple as high in overweight women compared to women with a normal weight (OR = 2.94 in the single regression and OR = 2.38 in the multiple regression). For having a good subjective physical health, the risk to develop MDD was rather low, however, but stable (OR = 0.33 in the single regression and OR = 0.35 in the multiple regression).

A question that is still unanswered is whether health-related factors also causally contribute to new onsets of MDD (Kraemer et al., 1997). Based on our results, the following hypothesis could be possible. Suffering from being overweight could have a negative effect on mood, self-confidence, self-image, and physical health, and so forth, which in turn results in developing depression over time. In contrast, having good physical health increases mood and self-confidence, might lead to a more positive self-image, and also contributes positively to physical health. To further support this, there is a growing number of studies showing that regular exercise prevents depressive symptoms (Mammen & Faulkner, 2013) and can reduce levels of depression (e.g., Gore, Farrell, & Gordon, 2001; Haslacher et al., 2015; Mammen & Faulkner, 2013). Here, Nyström, Neely, Hassmén, and Carlbring (2015) recommend exercising at least three times per week for 30 min each, and results of intervention studies even showed that this effect is comparable with antidepressants (Dinas, Koutedakis, & Flouris, 2011). In the context of smoking, a meta-analysis showed that those who quit smoking, compared to those who continue smoking, experienced reduced levels of depression, anxiety, and stress and had an improved positive mood and a better quality of life (Taylor et al., 2014). However, additional research is clearly warranted to further investigate this potential causal pathway. Further, it should be noted that the opposite causal direction is possible too, for example, having MDD leads to increased food intake as a form of self-medication. Hence, in order to fully understand the interplay of MDD and health-related factors, both pathways need to be investigated.

Another issue arises from a rather clinical perspective. That is, after bootstrapping, results of the multiple regression showed that obesity is a risk factor for developing MDD, whereas having good physical health was found to be a protective factor. Although we are slightly restricted in generalizing our findings given the specific sample that we tested, it is nevertheless important to start thinking about the (clinical) implications of our data, and maybe especially for young women, as they are about to start their own and independent future life. First, our data may be a further signal to governments and health providers that a healthy and active lifestyle is not only crucial from a physical health perspective, but also from a mental health perspective. As MDD has become the leading cause of disability worldwide (WHO, 2017), additional insights into risk and protective factors are thus vital when trying to alleviate this global burden. This is especially relevant given the facts that the recurrence rates for MDD are around 85% (Hardeveld, Spijker, De Graaf, Nolen, & Beekman, 2009) and that MDD becomes more persistent with each new episode (Steinert, Hofmann, Kruse, & Leichsenring, 2014). Hence, provision of information and communicating insights from science to official institutes, and of course to the public, is a crucial first step. A second important step is the implementation of the findings. Here, our data provide additional support for the further need to identify individuals at risk and to motivate these individuals to engage in prevention programs. Such programs should reduce risk and strengthen protective factors. When taking into account our specific findings, this thus implies that young women who suffer from obesity should be motivated and supported to lose weight. Regarding the protective factor of physical health, programs should be offered that help women to engage in regular physical exercise and to keep a healthy diet. As mentioned before, there are already promising findings showing that exercise has beneficial effects on depressive symptoms (e.g., Gore et al., 2001; Haslacher et al., 2015; Mammen & Faulkner, 2013) and on symptoms of emotional psychopathology in general (cf. Embry, 2011).

Our study is not without limitations. First, we used single items to describe some of the health-related factors. For example, participants' level of physical activity was examined with a single question. Here, it would have been relevant to, for example, distinguish between categories such as intensive regular, mild regular, mild non-regular, or intensive non-regular physical activity. Smoking was examined with three questions, but only a simple "yes/no" question without substantively differentiating potential smoking categories, for example, ranging from occasional to heavily dependent smoker, was used in the analyses. This limitation clearly limits the reliability and reduces the sensitivity of these two predictors, respectively. Second, the sample included, on average, well-educated women, and this could be considered as a limitation regarding the results' generalizability. Third, we did not maintain a constant time interval between baseline and follow-up assessment.

To summarize, the present findings provide new and valuable insights into the onset of MDD, that is, findings that are relevant for both clinical practice and theory. We showed that being overweight, being a smoker, and belonging to a high-risk drinking group predicted new onsets of MDD. At the same time, engaging in regular physical activity and having good physical health were found to be protective factors. These data provide many avenues for future research. It would be worthwhile to examine whether the risk and protective factors examined in this study are also considered as risk and protective factors in other areas of psychopathology, such as whether they are predictive of incidence of psychopathology. Further, there are various other factors that have the potential to be a risk factor for MDD, for example, MDD is characterized by elevated levels of negative imagery and impoverished positive imagery (for review, see Holmes, Blackwell,

Burnett Heyes, Renner, & Raes, 2016) and correlates with cognitive biases in attention, interpretation, and memory (for review, see, e.g., Everaert, Koster, & Derakshan, 2012; Gotlib & Joormann, 2010). However, whether they also robustly predict the onset of MDD has, to the best of our knowledge, not been (systematically) studied yet. Another important follow-up project would be the replication of the present data, including improvements on a methodological level, for example, testing a more representative sample and trying to include a larger sample to avoid low EPVs and in turn statistical compromises. Such follow-up is important because both MDD and the studied factors are considered as serious and remaining global health problems. Hence, advancing our understanding of their comorbidity and potential interplay is of great public interest.

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