Maturitas 155 (2022) 8–13

Contents lists available at ScienceDirect

Maturitas

journal homepage: www.elsevier.com/locate/maturitas

Original Article

Cross-sectional and prospective associations of lifestyle risk behaviors clustering with elevated depressive symptoms among middle-aged and older adults

André O. Werneck [a,*], Miguel Peralta [b,c], Riki Tesler [d], Adilson Marques [b,c]

[a] Center for Epidemiological Research in Nutrition and Health, Department of Nutrition, School of Public Health, University of São Paulo (USP), São Paulo, Brazil
[b] CIPER, Faculty of Human Kinetics, University of Lisbon, Lisbon, Portugal
[c] ISAMB, University of Lisbon, Lisbon, Portugal
[d] Department of Health Systems Management, Ariel University, Ariel, Israel

ARTICLE INFO

Keywords:
Exercise
Diet
Depression
Mood
Mental health

ABSTRACT

Objectives: To investigate the cross-sectional and prospective associations of lifestyle risk behaviors clustering with elevated depressive symptoms and to explore synergic prospective associations of different combinations of lifestyle risk behaviors with subsequent depressive symptoms.
Study design: Prospective cohort study. Data on 31,190 middle-aged and older adults from waves 4 (2011) and 6 (2015) of the Survey of Health, Ageing and Retirement in Europe (SHARE) were used.
Main outcome measures: Elevated depressive symptoms were estimated using the EURO-D 12-item scale. Lifestyle risk behaviors composing the cluster included physical inactivity, inadequate consumption of fruit and/or vegetables, binge drinking, and tobacco smoking. Gender, age group, education, place of residence, country, number of chronic diseases and body mass index were considered as confounders.
Results: With the exception of binge drinking, all lifestyle risk behaviors were associated with higher odds of elevated depressive symptoms in cross-sectional and prospective analyses. The clustering of unhealthy lifestyle behaviors was cross-sectionally associated with elevated depressive symptoms and the clustering of two [odds ratio [OR]: 1.39; 95%CI: 1.28–1.51) and three or four (OR: 1.60; 95%CI: 1.38–1.85) were prospectively associated with elevated depressive symptoms. There were no interactions between the pairs of behaviors in the association with later elevated depressive symptoms.
Conclusions: Our findings support the need for interventions integrating multiple health behaviors to prevent elevated depressive symptoms among middle-aged and older adults.

1. Introduction

Depression is one of the leading causes of disability worldwide [1,2]. Depression is associated with a reduced life expectancy, which is caused by the development of different comorbidities, such as cardiovascular diseases [3,4]. Specifically among older adults, depression is a serious health issue, as late-life depression is strongly associated with all-cause and cardiovascular mortality [5]. The etiology of depression is multifactorial different genetic, environmental and behavioral factors can contribute to its onset and development [4,6,7].

Among the health behaviors, dietary patterns, physical activity, tobacco smoking, and alcohol consumption are highlighted as important factors in the development of depression [6,8]. Other than the individual association of each risk factor with depression, studies have found that the clustering of multiple lifestyle behaviors is associated with later elevated depressive symptoms [9,10]. Examining clusters of health behaviors is of special interest, as behaviors can moderate each other or present additive effects in the association with later depressive symptoms. However, knowledge about this association among late middle-aged and older adults is still lacking, especially using multi-nation cohorts as some risk behaviors can be culture-dependent [11–14]. Also, the analysis of the synergic prospective associations of the lifestyle risk behavior combinations with later depressive symptoms is still warranted.

* Corresponding author at: Center for Epidemiological Research in Nutrition and Health, Department of Nutrition, School of Public Health, University of São Paulo (USP). *Av.* Dr. Arnaldo, 715 - Cerqueira César, São Paulo-SP, 01246-904, São Paulo, Brazil.
E-mail address: andrewerneck@usp.br (A.O. Werneck).

https://doi.org/10.1016/j.maturitas.2021.09.010
Received 19 March 2021; Received in revised form 6 August 2021; Accepted 22 September 2021
Available online 28 September 2021

Table 1
Characteristics of the sample (n = 31,190).

Variables	Categories	n (%) or mean ±
Baseline (Wave 4)		
Gender	Male	13,141 (42.1)
	Female	18,049 (57.9)
Age group	50–64	15,568 (49.9)
	65–79	13,055 (41.9)
	80+	2567 (8.2)
Education	Low	12,472 (40.0)
	Middle	12,151 (39.0)
	High	6567 (21.1)
Number of chronic diseases	n	1.69 ± 1.49
Body mass index	Kg/m^2	2.71 ± 1.14
Physical inactivity (≤ 1 day/week)	No	26,799 (85.9)
	Yes	4391 (14.1)
Daily consumption of fruits or vegetables	Yes	24,098 (77.3)
	No	7092 (22.7)
Binge drinking	No	25,447 (81.6)
	Yes	5743 (18.4)
Tobacco smoking	No	25,602 (82.1)
	Yes	5588 (17.9)
Clustering of unhealthy behaviors	0	14,977 (48.0)
	1	10,827 (34.7)
	2	4275 (13.7)
	3–4	1111 (3.6)
Elevated depressive symptoms	No	22,660 (72.7)
	Yes	8530 (27.4)
Follow-up (Wave 6)		
Elevated depressive symptoms	No	22,468 (72.0)
	Yes	8722 (28.0)

Note. Values are presented in absolute and relative frequencies or mean and standard deviation.

Therefore, we aimed to investigate the cross-sectional and prospective associations of a lifestyle risk behavior clustering with depressive symptoms, as well as to investigate the synergic prospective associations of different lifestyle risk behaviors combinations with subsequent depressive symptoms.

2. Methods

2.1. Sample

The present study used data from the Survey of Health, Ageing and Retirement in Europe (SHARE) study. The SHARE project aims to investigating different aspects of life after the age of 50 years, including the assessment of physical and mental health outcomes, socioeconomic factors, social networks and lifestyle behaviors [15]. SHARE has multiple waves for the present study, we used data from wave 4 (2011) and wave 6 (2015) as the wave 6 was the most updated wave with information on depressive symptoms for the complete sample. Austria, Germany, Sweden, Spain, Italy, France, Denmark, Switzerland, Belgium, Czech Republic, Poland, Portugal, Slovenia, and Estonia provided data in both waves. 53,568 participants presented valid data for the variables at wave 4 and 34,772 participated in both waves, but due to missing data, our final sample included 31,190 participants (Austria = 2729; Germany = 915; Sweden = 1286; Spain = 2250; Italy = 2183; France = 2908; Denmark = 1621; Switzerland = 2488; Belgium = 3225; Czech Republic = 3231; Poland = 1104; Portugal = 1250; Slovenia = 1747; Estonia = 4253). There were differences between the included and excluded sample. The included sample presented a slightly higher proportion of women (57.9% vs. 54.1%), highly educated participants (Included: Low: 40.0%, Middle: 39.0%, High: 21.1% vs. Excluded: Low: 43.5%, Middle: 38.3%, High: 18.3%) and was slightly younger (Included: 50–64y: 49.9%, 65–79y: 41.9%, 80+y: 8.2% vs. Excluded: 50–64y: 46.7%, 65–79y: 37.7%, 80+y: 15.7%). All measures were self-reported through interviews conducted by trained staff. All the procedures were approved by the local ethics committee in accordance with the principles expressed in the Declaration of Helsinki.

2.2. Depressive symptoms

For depressive symptoms, we used the EURO-D scale. The scale is composed of 12 dichotomic (yes or not) items, which inquire about depressed mood, pessimism, suicidality, guilt, sleep, interest, irritability, appetite, fatigue, concentration, enjoyment, and tearfulness. The final score ranges between 0 and 12 and the adopted cut-off point for indicating elevated depressive symptoms is ≥4. The questionnaire was previously validated using samples of different European countries [16]. Even the questionnaire being developed and validated among older adults, a previous study found only minor differences comparing with the centre for Epidemiologic Studies of Depression among middle-aged adults [17].

2.3. Lifestyle behaviors

Physical inactivity was estimated through questions asking about the weekly frequency of moderate and vigorous physical activities. The possible answers were: “more than once a week”, “once a week”, “up to three times a month”, and “hardly ever or never”. We considered physical inactivity to be those participants who reported no regular moderate or vigorous physical activity (less than once a week). Fruit and / or vegetable consumption was assessed through a question asking about the frequency of fruit or vegetable ingestion. Possible answers were “less than once a week”, “once a week”, “twice a week”, “3–6 times a week” or “every day”. We considered patients who reported consuming fruits and / or vegetables less than once a day to have

Table 2
Cross-sectional and prospective associations between different behaviors and elevated depressive symptoms.

	Elevated depressive symptoms (wave 4)		Elevated depressive symptoms (wave 6)	
	Crude OR (95%CI)	Adjusted OR (95%CI)	Crude OR (95%CI)	Adjusted OR (95%CI)
Physical inactivity				
No	Ref	Ref	Ref	Ref
Yes	2.14 (2.00–2.29)	1.66 (1.55–1.78)	1.96 (1.82–2.10)	1.61 (1.50–1.74)
Daily consumption of fruits or vegetables				
Yes	Ref	Ref	Ref	Ref
No	1.17 (1.10–1.24)	1.26 (1.19–1.35)	1.11 (1.05–1.19)	1.19 (1.11–1.27)
Binge drinking				
No	Ref	Ref	Ref	Ref
Yes	0.71 (0.67–0.76)	1.02 (0.95–1.10)	0.76 (0.71–0.82)	1.01 (0.93–1.09)
Tobacco smoking				
No	Ref	Ref	Ref	Ref
Yes	1.01 (0.94–1.07)	1.15 (1.07–1.23)	0.95 (0.89–1.02)	1.14 (1.06–1.22)

Note. Adjusted for gender, age group, education, country, number of chronic diseases and body mass index during wave 4. The adjusted prospective models also included depressive symptoms during the baseline (wave 4). Abbreviation: OR, odds ratio; CI, confidence interval.

Table 3
Joint associations of different lifestyle behaviors during wave 4 (2011/12) and elevated depressive symptoms during wave 6 (2015).

		Interactions		
Joint associations	**OR (95% CI)**	**Multiplicative**	**RERI**	**AP**
Physical inactivity + without daily consumption of Fruits/ vegetables		0.92 (0.78–1.08)	−0.05 (−0.31 – 0.22)	−0.03 (−0.18 – 0.12)
No + No	REF			
Yes + No	1.63 (1.50–1.78)			
No + Yes	1.17 (1.09–1.26)			
Yes + Yes	1.76 (1.55–1.99)			
Physical inactivity + Binge drinking		0.93 (0.75–1.15)	−0.10 (−0.42 – 0.22)	−0.06 (−0.28 – 0.15)
No + No	REF			
Yes + No	1.63 (1.50–1.76)			
No + Yes	1.02 (0.94–1.11)			
Yes + Yes	1.55 (1.29–1.88)			
Physical inactivity + Tobacco smoking		1.07 (0.88–1.29)	0.18 (−0.15 – 0.51)	0.10 (−0.06 – 0.26)
No + No	REF			
Yes + No	1.59 (1.46–1.72)			
No + Yes	1.11 (1.03–1.20)			
Yes + Yes	1.89 (1.61–2.22)			
Without daily consumption of Fruits/ vegetables + Binge drinking		0.90 (0.77–1.06)	−0.11 (−0.29 – 0.07)	−0.10 (−0.27 – 0.07)
No + No	REF			
Yes + No	1.21 (1.13–1.30)			
No + Yes	1.02 (0.94–1.12)			
Yes + Yes	1.12 (0.99–1.27)			
Without daily consumption of Fruits/ vegetables + tobacco smoking		1.01 (0.86–1.17)	0.03 (−0.16 – 0.22)	0.02 (−0.12 – 0.16)
No + No	REF			
Yes + No	1.17 (1.09–1.26)			
No + Yes	1.11 (1.02–1.21)			
Yes + Yes	1.31 (1.17–1.47)			
Binge drinking + tobacco smoking		1.09 (0.92–1.29)	0.10 (−0.09 – 0.28)	0.08 (−0.07 – 0.23)
No + No	REF			
Yes + No	1.11 (1.03–1.21)			
No + Yes	0.97 (0.89–1.06)			
Yes + Yes	1.18 (1.04–1.35)			

Note. Adjusted for gender, age group, education, country, number of chronic diseases, depressive symptoms and body mass index during the wave 4. OR, odds ratio. CI, confidence interval. RERI, relative excess risk due to interaction. AP, attributable proportion.

inadequate consumption. For binge drinking, participants were asked "how often do you have six or more drinks on one occasion?", with the possible answers: "1) Daily or almost every day; 2) Five or six days a week; 3) Three or four days a week; 4) Once or twice a week; 5) Once or twice a month; 6) Less than once a month; 7) Not at all in the last 3 months". We considering at least once a month as positive screening for bing drinking.. Current tobacco smoking was also assessed and included as a dichotomic variable (yes/no). We created a cluster variable considering the sum of physical inactivity, inadequate consumption of fruits and/or vegetables, binge drinking and tobacco smoking; these were classified as either no lifestyle risk behaviors, one lifestyle risk behavior, two lifestyle risk behaviors, and three or four lifestyle risk behaviors.

2.4. Confounders

We considered gender, age group, education, living place, number of chronic diseases and body mass index as confounders. Age groups were classified as 50–64y, 65–79y, and 80+*y*. Education was classified according to the International Standard Classification of Education-97 codes (low education: codes 1 and 2, middle education: codes 3 and 4, high education: codes 5 and 6). Place of living was classified as big city, suburbs of a big city, large town, small town or rural area. Chronic diseases included cardiovascular diseases, hypertension, cholesterol, stroke, diabetes, lung disease, asthma, arthritis, osteoporosis, cancer, ulcer, Parkinson's disease, cataracts, hip femoral fracture, or others. Body mass index was estimated using self-reported values of stature and body mass.

2.5. Statistical procedures

Values of absolute and relative frequencies as well as mean and standard deviation were used for descriptive statistics. Logistic regression models, reporting odds ratio (OR) and 95% confidence intervals (CI) were used for the cross-sectional and prospective associations of different lifestyle risk behaviors and elevated depressive symptoms as well as for the cross-sectional and prospective association of lifestyle risk behaviors clustering and elevated depressive symptoms. The multiplicative and additive interactions (using relative excess risk due to interaction – [RERI], and proportion of disease attributable to interaction [AP]) were used to analyze the synergic prospective associations of different lifestyle behaviors combinations with elevated depressive symptoms. All analyses were conducted using the software Stata 15.1 (StataCorp, College Station, TX).

3. Results

The final sample included 31,190 adults (57.9% women). Table 1 shows the characteristics of the sample. There were 14.1% who presented physical inactivity (≤1 day/week), 22.7% did not consume fruits and/or vegetables daily, 18.4% presented binge drinking and 17.9% reported to smoke tobacco. There were 28.0% of the participants who showed elevated depressive symptoms during the follow-up.

The cross-sectional (exposures and outcome during wave 4 [2011]) and prospective associations (exposures at wave 4 and outcome at wave 6 [2015]) of each behavioral risk factor and elevated depressive symptoms are presented in Table 2. Physical inactivity (cross-sectional: OR: 1.66, 95%CI: 1.55–1.78; prospective: OR: 1.61, 95%CI: 1.50–1.74), inadequate consumption of fruits and vegetables (cross-sectional: OR: 1.26, 95%CI: 1.19–1.35; prospective: OR: 1.19, 95%CI: 1.11–1.27) and tobacco smoking (cross-sectional: OR: 1.15, 95%CI: 1.07–1.23; prospective: OR: 1.14, 95%CI: 1.06–1.22) were associated with higher odds for elevated depressive symptoms.

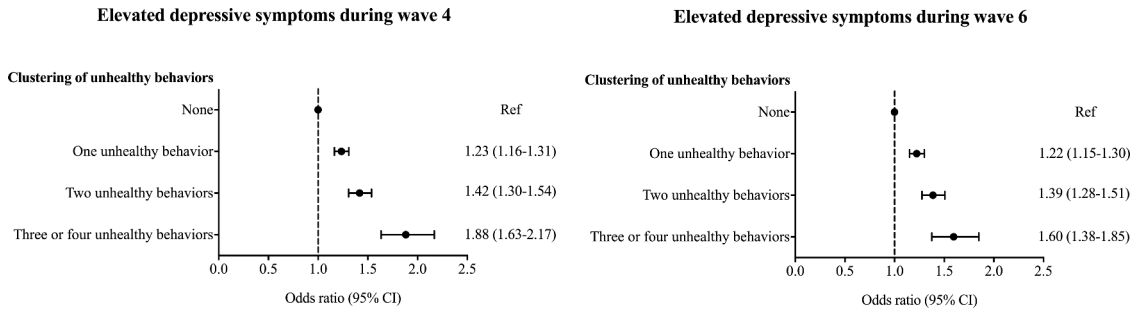

Fig. 1. Cross-sectional and prospective associations of the clustering of unhealthy behaviors and elevated depressive symptoms.
Note. Adjusted for gender, age group, education, country, number of chronic diseases and body mass index during wave 4. The adjusted prospective models also included depressive symptoms during the baseline (wave 4). CI, confidence interval. Crude analyses: Clustering of unhealthy behaviors and elevated depressive symptoms during wave 4: None = Ref, one unhealthy behavior: 1.18 (1.12–1.25), two unhealthy behaviors: 1.24 (1.15–1.34), three or four unhealthy behaviors: 1.38 (1.21–1.57). Clustering of unhealthy behaviors and elevated depressive symptoms during wave 6: None = Ref, one unhealthy behavior: 1.21 (1.15–1.28), two unhealthy behaviors: 1.28 (1.18–1.38), three or four unhealthy behaviors: 1.31 (1.15–1.49).

Table 3 shows the joint prospective associations of different combinations of health behaviors during wave 4 and elevated depressive symptoms during wave 6. There were no additive neither multiplicative interactions between the lifestyle behaviors in the prediction of elevated depressive symptoms.

The cross-sectional and prospective associations between clustering of unhealthy behaviors and elevated depressive symptoms are presented in Fig. 1. The presence of one health behavior (cross-sectional: OR: 1.23, 95%CI: 1.16–1.31; prospective: OR: 1.22, 95%CI: 1.15–1.30), clustering of two (cross-sectional: OR: 1.42, 95%CI: 1.30–1.54; prospective: OR: 1.39, 95%CI: 1.28–1.51), and three or four (cross-sectional: OR: 1.88, 95%CI: 1.63–2.17; prospective: OR: 1.60, 95%CI: 1.38–1.85) were associated with elevated depressive symptoms in both cross-sectional and prospective analysis. In general, the combinations that included physical inactivity presented higher odds for elevated depressive symptoms (Supplementary Table A).

4. Discussion

We aimed to investigate whether the clustering of lifestyle behaviors was prospectively associated with elevated depressive symptoms among adults. Our main findings revealed that physical inactivity, inadequate consumption of fruits or vegetables, and tobacco smoking were associated with current and later elevated depressive symptoms. Also, the risk for elevated depressive symptoms increased with the increment of unhealthy lifestyle behaviors in the cross-sectional and prospective analyzes. However, we found no interactions between specific pairs of lifestyle behaviors in the association with later elevated depressive symptoms.

Our findings are in line with previous studies about the association of different lifestyle behaviors with elevated depressive symptoms among older adults [4,6,8,9,18]. and the benefits of clustering healthy behaviors regarding depressive symptoms [9,10]. Both cross-sectional and prospective associations showed a trend in the risk of elevated depressive symptoms with the increment of unhealthy lifestyle behaviors, with the clustering three or four lifestyle risk behaviors being associated with higher odds of presenting elevated depressive symptoms than having none one, or two. This finding is in line with the discussion of the importance of integrating different lifestyle behaviors in the formulation of policies aiming to prevent mental disorders [4]. However, important differences were noted as binge drinking did not add risk for later elevated depressive symptoms and physical inactivity was the main unhealthy lifestyle behavior in our sample [10,19]. The binge drinking indicator we adopted may include more participants than the previous articles that used regular heavy drinking indicators, which could underestimate the risk of developing high depressive symptoms. On the other hand, we found that even the practice of low amounts of physical activity (i.e. at least one day/week) was associated with lower odds for elevated depressive symptoms, which is in line with previous findings regarding the dose-response association between leisure-time physical activity and depressive symptoms [20,21].

Each risk factor can have different mechanisms connected to depressive symptoms [22–26]. However, considering that there was a trend in the risk for elevated depressive symptoms according to the unhealthy lifestyle behaviors, some of the mechanisms may be shared by the different lifestyle behaviors. Among the potentially shared mechanisms, inflammation and oxidative stress are highlighted as a common consequence of physical inactivity [27,28], poorer diet habits [23,29,30], tobacco smoking [31,32] and binge drinking [33] and both inflammation and oxidative stress are associated with the development of depressive symptoms [29,34]. Therefore, the clustering of unhealthy lifestyle behaviors could decrease the threshold for these conditions to affect the risk of elevated depressive symptoms or even increase the risk of depressive symptoms more intensely than expected based on the simple sum of each unhealthy lifestyle's individual effect behaviors.

Our study used a large cohort with four years of follow-up data on middle-aged and older adults from different European countries. We consider this as our main strength, especially considering the increased prevalence of lifestyle risk behaviors in this age group. However, our findings should be inferred in light of potential limitations. First, all measures were self-reported, and even being widely used in previous studies, the specific questions regarding lifestyle behaviors were not validated in the SHARE cohort, which can contain recall bias. Second, the assessment of fruit or vegetable intake and physical activity were based solely on the weekly frequency and number of portions of fruits and vegetables. Thus, the amount and intensity of physical activity, along with portion size, were not available. Third, there was considerable missing data during all the waves [15], which can compromise the representativity. Fourth, other potential confounders were not considered in the analyzes because data was not available (e.g. family history of depressive disorders, anxiety disorders).

5. Conclusions

In summary, the clustering of unhealthy behaviors is cross-sectionally and prospectively associated with elevated depressive symptoms. Our findings lead to different implications as the need for integrative interventions to tackle multiple health behaviors. Future studies should investigate which mediators lifestyle behaviors share in the association with elevated depressive symptoms, which could help formulate intervention strategies. Furthermore, intervention strategies should adopt a more comprehensive view of healthy behaviors to prevent depressive symptoms.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. André Werneck is supported by the São Paulo Research Foundation (FAPESP) with a PhD scholarship (FAPESP process: 2019/24124–7). This paper presents independent research. The views expressed in this publication are those of the authors and not necessarily those of the acknowledged institution.

Ethical approval

All the procedures were approved by the Ethics Committee of the University of Mannheim, in accordance with the principles expressed in the Declaration of Helsinki. More details can be found in the released documents (http://www.share-project.org/fileadmin/pdf_documentation/MPG_Ethics_Council_SHARE_overall_approval_29.05.2020_en_.pdf).

Provenance and peer review

This article was not commissioned and was externally peer reviewed.

Research data (data sharing and collaboration)

Share data is available upon request. More information can be found on the website: http://www.share-project.org/home0.html

CRediT authorship contribution statement

André O. Werneck: Conceptualization, Formal analysis, Visualization, Writing – original draft. **Miguel Peralta:** Visualization, Validation, Writing – review & editing. **Riki Tesler:** Visualization, Validation, Writing – review & editing. **Adilson Marques:** Visualization, Validation, Writing – review & editing.

Conflict of interest

The authors declare that they have no competing interests.

Acknowledgments

This paper uses data from SHARE Waves 4, and 6 (DOIs: 10.6103/SHARE.w4.710 and 10.6103/SHARE.w6.710), see Börsch-Supan et al. (2013) for methodological details. The SHARE data collection has been funded by the European Commission, DG RTD through FP5 (QLK6-CT-2001-00360), FP6 (SHARE-I3: RII-CT-2006-062193, COMPARE: CIT5-CT-2005-028857, SHARELIFE: CIT4-CT-2006-028812), FP7 (SHARE-PREP: GA N°211909, SHARE-LEAP: GA N°227822, SHARE M4: GA N°261982, DASISH: GA N°283646) and Horizon 2020 (SHARE-DEV3: GA N°676536, SHARE-COHESION: GA N°870628, SERISS: GA N°654221, SSHOC: GA N°823782) and by DG Employment, Social Affairs & Inclusion through VS 2015/0195, VS 2016/0135, VS 2018/0285, VS 2019/0332, and VS 2020/0313. Additional funding from the German Ministry of Education and Research, the Max Planck Society for the Advancement of Science, the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, OGHA_04-064, HHSN271201300071C, RAG052527A) and from various national funding sources is gratefully acknowledged (see www.share-project.org).

References

[1] A.J. Ferrari, F.J. Charlson, R.E. Norman, S.B. Patten, G. Freedman, C.J.L. Murray, T. Vos, H.A. Whiteford, Burden of depressive disorders by country, sex, age, and year: findings from the Global Burden of Disease Study 2010, PLoS Med. 10 (2013), e1001547, https://doi.org/10.1371/journal.pmed.1001547.

[2] Q. Liu, H. He, J. Yang, X. Feng, F. Zhao, J. Lyu, Changes in the global burden of depression from 1990 to 2017: findings from the Global Burden of Disease study, J. Psychiatr. Res. 126 (2020) 134–140, https://doi.org/10.1016/j.jpsychires.2019.08.002.

[3] C.U. Correll, M. Solmi, N. Veronese, B. Bortolato, S. Rosson, P. Santonastaso, N. Thapa-Chhetri, M. Fornaro, D. Gallicchio, E. Collantoni, G. Pigato, A. Favaro, F. Monaco, C. Kohler, D. Vancampfort, P.B. Ward, F. Gaughran, A.F. Carvalho, B. Stubbs, Prevalence, incidence and mortality from cardiovascular disease in patients with pooled and specific severe mental illness: a large-scale meta-analysis of 3,211,768 patients and 113,383,368 controls, World Psychiatry 16 (2017) 163–180, https://doi.org/10.1002/wps.20420.

[4] J. Firth, N. Siddiqi, A. Koyanagi, D. Siskind, S. Rosenbaum, C. Galletly, S. Allan, C. Caneo, R. Carney, A.F. Carvalho, M.L. Chatterton, C.U. Correll, J. Curtis, F. Gaughran, A. Heald, E. Hoare, S.E. Jackson, S. Kisely, K. Lovell, M. Maj, P. D. McGorry, C. Mihalopoulos, H. Myles, B. O'Donoghue, T. Pillinger, J. Sarris, F. B. Schuch, D. Shiers, L. Smith, M. Solmi, S. Suetani, J. Taylor, S.B. Teasdale, G. Thornicroft, J. Torous, T. Usherwood, D. Vancampfort, N. Veronese, P.B. Ward, A.R. Yung, E. Killackey, B. Stubbs, The Lancet Psychiatry Commission: a blueprint for protecting physical health in people with mental illness, Lancet Psychiatry 6 (2019) 675–712, https://doi.org/10.1016/S2215-0366(19)30132-4.

[5] J. Wei, R. Hou, X. Zhang, H. Xu, L. Xie, E.K. Chandrasekar, M. Ying, M. Goodman, The association of late-life depression with all-cause and cardiovascular mortality among community-dwelling older adults: systematic review and meta-analysis, Br. J. Psychiatry 215 (2019) 449–455, https://doi.org/10.1192/bjp.2019.74.

[6] J. Firth, M. Solmi, R.E. Wootton, D. Vancampfort, F.B. Schuch, E. Hoare, S. Gilbody, J. Torous, S.B. Teasdale, S.E. Jackson, L. Smith, M. Eaton, F.N. Jacka, N. Veronese, W. Marx, G. Ashdown-Franks, D. Siskind, J. Sarris, S. Rosenbaum, A. F. Carvalho, B. Stubbs, A meta-review of "lifestyle psychiatry": the role of exercise, smoking, diet and sleep in the prevention and treatment of mental disorders, World Psychiatry 19 (2020) 360–380, https://doi.org/10.1002/wps.20773.

[7] R.V. Saveanu, C.B. Nemeroff, Etiology of depression: genetic and environmental factors, Psychiatr. ClinicsNorth Am. 35 (2012) 51–71, https://doi.org/10.1016/j.psc.2011.12.001.

[8] J. Sarris, R. Thomson, F. Hargraves, M. Eaton, M. de Manincor, N. Veronese, M. Solmi, B. Stubbs, A.R. Yung, J. Firth, Multiple lifestyle factors and depressed mood: a cross-sectional and longitudinal analysis of the UK Biobank (N = 84,860), BMC Med. 18 (2020) 354, https://doi.org/10.1186/s12916-020-01813-5.

[9] M. Adjibade, C. Lemogne, C. Julia, S. Hercberg, P. Galan, K.E. Assmann, E. Kesse-Guyot, Prospective association between combined healthy lifestyles and risk of depressive symptoms in the French NutriNet-Santé cohort, J. Affect. Disord. 238 (2018) 554–562, https://doi.org/10.1016/j.jad.2018.05.038.

[10] A. Fukunaga, Y. Inoue, T. Kochi, H. Hu, M. Eguchi, K. Kuwahara, T. Miki, K. Kurotani, A. Nanri, I. Kabe, T. Mizoue, Prospective study on the association between adherence to healthy lifestyles and depressive symptoms among Japanese employees: the Furukawa Nutrition and Health Study, J. Epidemiol. 30 (2020) 288–294, https://doi.org/10.2188/jea.JE20190018.

[11] J.N. Hall, S. Moore, S.B. Harper, J.W. Lynch, Global variability in fruit and vegetable consumption, Am. J. Prev. Med. 36 (2009) 402–409, https://doi.org/10.1016/j.amepre.2009.01.029, e5.

[12] M. Ng, M.K. Freeman, T.D. Fleming, M. Robinson, L. Dwyer-Lindgren, B. Thomson, A. Wollum, E. Sanman, S. Wulf, A.D. Lopez, C.J.L. Murray, E. Gakidou, Smoking prevalence and cigarette consumption in 187 countries, 1980-2012, JAMA 311 (2014) 183, https://doi.org/10.1001/jama.2013.284692.

[13] M. Sudhinaraset, C. Wigglesworth, D.T. Takeuch, Social and cultural contexts of alcohol use: influences in a social–ecological framework, Alcohol Res. 38 (2016) 35–45.

[14] J. Unger, T. Cruz, L. Baezconde-Garbanati, S. Shakib, P. Palmer, C.A. Johnson, A. Shields, J. Cruz, J. Mock, E. Edsall, T. Glynn, E. Gritz, Exploring the cultural context of tobacco use: a transdisciplinary framework, Nicotine Tobacco Res 5 (2003) 101–107, https://doi.org/10.1080/1462220031000162554 6.

[15] A. Börsch-Supan, M. Brandt, C. Hunkler, T. Kneip, J. Korbmacher, F. Malter, B. Schaan, S. Stuck, S. Zuber, Data resource profile: the survey of health, ageing and retirement in Europe (SHARE), Int. J. Epidemiol. 42 (2013) 992–1001, https://doi.org/10.1093/ije/dyt088.

[16] M.J. Prince, F. Reischies, A.T.F. Beekman, R. Fuhrer, C. Jonker, S.-.L. Kivela, B. A. Lawlor, A. Lobo, H. Magnusson, M. Fichter, H. Van Oyen, M. Roelands, I. Skoog, C. Turrina, J.R.M. Copeland, Development of the EURO–D scale – a European Union initiative to compare symptoms of depression in 14 European centres, Br. J. Psychiatry 174 (1999) 330–338, https://doi.org/10.1192/bjp.174.4.330.

[17] E. Courtin, M. Knapp, E. Grundy, M. Avendano-Pabon, Are different measures of depressive symptoms in old age comparable? An analysis of the CES-D and Euro-D scales in 13 countries: comparability of the CES-D and Euro-D Scales of Depressive Symptoms in 13 Countries, Int. J. Methods Psychiatr. Res. 24 (2015) 287–304, https://doi.org/10.1002/mpr.1489.

[18] A. Marques, J. Bordado, M. Peralta, E.R. Gouveia, R. Tesler, Y. Demetriou, D. G. Baya, Cross-sectional and prospective relationship between physical activity and depression symptoms, Sci. Rep. 10 (2020) 16114, 10.1038/s41598-020-72987-4.

[19] K.E. Champion, M. Mather, B. Spring, F. Kay-Lambkin, M. Teesson, N.C. Newton, Clustering of multiple risk behaviors among a sample of 18-year-old Australians and associations with mental health outcomes: a latent class analysis, Front. Public Health. 6 (2018) 135, https://doi.org/10.3389/fpubh.2018.00135.

[20] A.O. Werneck, A.L. Oyeyemi, D.R. Silva, Physical activity and depression: is 150min/week of moderate to vigorous physical activity a necessary threshold for decreasing risk of depression in adults? Different views from the same data, Soc. Psychiatry Psychiatr. Epidemiol. 53 (2018) 323–324, https://doi.org/10.1007/s00127-018-1490-5.

[21] F.B. Schuch, A.O. Werneck, D. Vancampfort, B. Stubbs, M. Teychene, P.A. Lotufo, I. Benseñor, A.R. Brunoni, Cross-sectional associations of leisure and transport related physical activity with depression and anxiety, J. Psychiatr. Res. 140 (2021) 228–234, https://doi.org/10.1016/j.jpsychires.2021.05.053.
[22] J.M. Boden, D.M. Fergusson, Alcohol and depression: alcohol and depression, Addiction 106 (2011) 906–914, https://doi.org/10.1111/j.1360-0443.2010.03351.x.
[23] J. Firth, J.E. Gangwisch, A. Borisini, R.E. Wootton, E.A. Mayer, Food and mood: how do diet and nutrition affect mental wellbeing? BMJ 369 (2020) m2440, https://doi.org/10.1136/bmj.m2440.
[24] A. Kandola, G. Ashdown-Franks, J. Hendrikse, C.M. Sabiston, B. Stubbs, Physical activity and depression: towards understanding the antidepressant mechanisms of physical activity, Neurosci. Biobehav. Rev. 107 (2019) 525–539, https://doi.org/10.1016/j.neubiorev.2019.09.040.
[25] W. Marx, M. Lane, M. Hockey, H. Aslam, M. Berk, K. Walder, A. Borsini, J. Firth, C. M. Pariante, K. Berding, J.F. Cryan, G. Clarke, J.M. Craig, K.-.P. Su, D. Mischoulon, F. Gomez-Pinilla, J.A. Foster, P.D. Cani, S. Thuret, H.M. Staudacher, A. Sánchez-Villegas, H. Arshad, T. Akbaraly, A. O'Neil, T. Segasby, F.N. Jacka, Diet and depression: exploring the biological mechanisms of action, Mol. Psychiatry 26 (2021) 134–150, https://doi.org/10.1038/s41380-020-00925-x.
[26] A.R. Mathew, L. Hogarth, A.M. Leventhal, J.W. Cook, B. Hitsman, Cigarette smoking and depression comorbidity: systematic review and proposed theoretical model: smoking and depression, Addiction 112 (2017) 401–412, https://doi.org/10.1111/add.13604.
[27] C.V. de Sousa, M.M. Sales, T.S. Rosa, J.E. Lewis, R.V. de Andrade, H.G. Simões, The antioxidant effect of exercise: a systematic review and meta-analysis, Sports Med. 47 (2017) 277–293, https://doi.org/10.1007/s40279-016-0566-1.
[28] M. Hamer, S. Sabia, G.D. Batty, M.J. Shipley, A.G. Tabák, A. Singh-Manoux, M. Kivimaki, Physical activity and inflammatory markers over 10 years: follow-up in men and women from the Whitehall II cohort study, Circulation 126 (2012) 928–933, 10.1161/CIRCULATIONAHA.112.103879.
[29] M. Berk, L.J. Williams, F.N. Jacka, A. O'Neil, J.A. Pasco, S. Moylan, N.B. Allen, A. L. Stuart, A.C. Hayley, M.L. Byrne, M. Maes, So depression is an inflammatory disease, but where does the inflammation come from? BMC Med. 11 (2013) https://doi.org/10.1186/1741-7015-11-200.
[30] C. Rooney, M.C. McKinley, J.V. Woodside, The potential role of fruit and vegetables in aspects of psychological well-being: a review of the literature and future directions, Proc. Nutr. Soc. 72 (2013) 420–432, 10.1017/S0029665113003388.
[31] B. Isik, A. Ceylan, R. Isik, Oxidative stress in smokers and non-smokers, Inhal. Toxicol. 19 (2007) 767–769, https://doi.org/10.1080/08958370701401418.
[32] V. Reichert, X. Xue, D. Bartscherer, D. Jacobsen, C. Fardellone, P. Folan, N. Kohn, A. Talwar, C.N. Metz, A pilot study to examine the effects of smoking cessation on serum markers of inflammation in women at risk for cardiovascular disease, Chest 136 (2009) 212–219, https://doi.org/10.1378/chest.08-2288.
[33] M.R. Piano, A. Mazzuco, M. Kang, S.A. Phillips, Cardiovascular consequences of binge drinking: an integrative review with implications for advocacy, policy, and research, Alcohol Clin. Exp. Res. 41 (2017) 487–496, https://doi.org/10.1111/acer.13329.
[34] T. Liu, S. Zhong, X. Liao, J. Chen, T. He, S. Lai, Y Jia, A meta-analysis of oxidative stress markers in depression, PLoS One 10 (2015), e0138904, https://doi.org/10.1371/journal.pone.0138904.