



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



# The association between depression symptoms, psychological burden caused by Covid-19 and physical activity: An investigation in Germany, Italy, Russia, and Spain

Julia Brailovskaia<sup>a,\*</sup>, Fiammetta Cosci<sup>b</sup>, Giovanni Mansueto<sup>b</sup>, Marta Miragall<sup>c,d</sup>, Rocío Herrero<sup>d,e</sup>, Rosa M. Baños<sup>c,d,e</sup>, Yulia Krasavtseva<sup>f,g,h</sup>, Yakov Kochetkov<sup>h</sup>, Jürgen Margraf<sup>a</sup>

<sup>a</sup> Mental Health Research and Treatment Center, Department of Clinical Psychology and Psychotherapy, Ruhr-Universität Bochum, Bochum, Germany

<sup>b</sup> Department of Health Sciences, University of Florence, Florence, Italy

<sup>c</sup> Department of Personality, Evaluation, and Psychological Treatments, University of Valencia, Valencia, Spain

<sup>d</sup> CIBER Fisiopatología Obesidad y Nutrición (CIBEROBN), Instituto Carlos III, Madrid, Spain

<sup>e</sup> Instituto Polibienestar, University of Valencia, Valencia, Spain. Av. Blasco Ibáñez 21, Valencia, Spain

<sup>f</sup> Department of Pedagogy and Medical Psychology, Federal State Autonomous Educational Institution of Higher Education I.M. Sechenov First Moscow State Medical University of the Ministry of Health of the Russian Federation (Sechenov University), Moscow, Russian

<sup>g</sup> Department of Psychology, Lomonosov Moscow State University, Moscow, Russian

<sup>h</sup> Center for Cognitive Therapy, Moscow, Russia

## ARTICLE INFO

### Keywords:

Burden by covid-19  
Depression  
Physical activity  
Germany  
Italy  
Russia  
Spain

## ABSTRACT

The outbreak of Covid-19 required the re-organization of everyday life. While some people accepted this challenge, other experienced the current situation as a heavy burden that impedes the adaptation to the new life conditions. The present study investigated factors that can impact the level of burden caused by Covid-19. Burden, depression symptoms and frequency of physical activity (e.g., jogging, cycling) were assessed via online surveys in overall 1,931 people from four countries (Germany: N = 625; Italy: N = 936; Russia: N = 230; Spain: N = 140). Similar result patterns were found in all country-specific samples. Burden by Covid-19 was significantly positively associated with depression symptoms, while it was significantly negatively linked to physical activity. Moreover, physical activity buffered the association between depression symptoms and burden. The present cross-national findings emphasize the protective effect of physical activity specifically in times of Covid-19. This issue should be addressed in governmental programs to longitudinally protect mental and physical health and to enhance the willingness to adhere to the anti-Covid-19 measures among the population.

## 1. Introduction

The outbreak of the coronavirus disease 2019 (Covid-19; severe acute respiratory syndrome coronavirus 2, SARS-CoV-2) significantly changed everyday life. In March of 2020, it was recognized as a pandemic (World Health Organization, 2020b). By September 30, 2020, there were more than 33.71 million confirmed infections and more than 1,008,000 deaths worldwide (see <https://github.com/owid/covid-19-data/tree/master/public/data>). To slow down the spread of the pandemic, many governments introduced extraordinary measures that

reduced physical contact among the population (so-called “social distancing”) (World Health Organization, 2020a). The measures varied between and within countries, but mainly included bans on non-family gatherings and travel, cancellation of mass events, temporary closure of public institutions, non-essential businesses, and entertainment venues; a “stay-at-home” was requested or ordered by many governments and authorities (Sohrabi et al., 2020). Behavioral measures, such as the wearing of face masks and maintaining of distance to other people in public places, became mandatory in many countries (Tso and Cowling, 2020).

\* Corresponding author at: Mental Health Research and Treatment Center of Ruhr-Universität Bochum, Massenbergr. 9-13, 44787 Bochum, Germany.

E-mail addresses: [Julia.Brailovskaia@rub.de](mailto:Julia.Brailovskaia@rub.de) (J. Brailovskaia), [fiammetta.cosci@unifi.it](mailto:fiammetta.cosci@unifi.it) (F. Cosci), [giovanni.mansueto@unifi.it](mailto:giovanni.mansueto@unifi.it) (G. Mansueto), [Marta.Miragall@uv.es](mailto:Marta.Miragall@uv.es) (M. Miragall), [ro.herrero.09@gmail.com](mailto:ro.herrero.09@gmail.com) (R. Herrero), [Rosa.Banos@uv.es](mailto:Rosa.Banos@uv.es) (R.M. Baños), [julia.k7@gmail.com](mailto:julia.k7@gmail.com) (Y. Krasavtseva), [kochet77@gmail.com](mailto:kochet77@gmail.com) (Y. Kochetkov), [Juergen.Margraf@rub.de](mailto:Juergen.Margraf@rub.de) (J. Margraf).

<https://doi.org/10.1016/j.psychres.2020.113596>

Received 3 October 2020; Accepted 23 November 2020

Available online 26 November 2020

0165-1781/© 2020 Elsevier B.V. All rights reserved.

The extraordinary situation caused by Covid-19 and the introduction of the governmental measures have produced wide-ranging reactions in the populations. Some individuals experience a heavy psychological burden: They feel overwhelmed by the current situation that typically results in a negative emotional response characterized by frustration, anxiety, and uncertainty. As a consequence, they have significant problems to manage everyday life and to fulfill their obligations under the new conditions (Taylor et al., 2020). Other people experience the current situation as less burdensome and react in an adaptive way. They try to maintain a daily routine as far as possible (Brailovskaia and Margraf, 2020b). The way people perceive and deal with the current Covid-19 situation significantly influences their mental and physical health (Taylor et al., 2020). Moreover, it impacts their adherence to actively participate in the governmental measures such as wearing of face masks (Gandhi and Rutherford, 2020). The level of adherence and cooperation among the population determines the success of the governmental measures in fighting the pandemic (Galea et al., 2020). Against this background, it is urgent to investigate factors that can predict the level of psychological burden caused by the current Covid-19 situation. This knowledge can be used to identify persons at risk for a high burden experience, to reduce it, and thus to longitudinally protect mental and physical health and to enhance adherence to the anti-Covid-19 measures.

Previous research described an increase of depression symptoms in the last decade, especially among the younger population (Brailovskaia and Margraf, 2020a; Twenge et al., 2019). Recent studies predicted a further increase of the symptoms during the Covid-19 pandemic (Bueno-Notivol et al., 2020; Galea et al., 2020). Individuals with enhanced levels of depression symptoms are characterized by feelings of control loss, hopelessness, and helplessness (Buysse et al., 2008; Lei et al., 2016). They tend to ruminate and are overwhelmed by the requirement to adapt to new uncertain situations (Spasojević and Alloy, 2001). Low self-efficacy and the lack of adequate coping strategies often contribute to maladaptive reactions such as social withdrawal, excessive worries, or suicide ideation and behavior (Gorday et al., 2018; Schönfeld et al., 2016). Based on this background, it can be assumed that depression symptoms might belong to factors that foster the experience of psychological burden by the Covid-19 situation (Bueno-Notivol et al., 2020). This could be true especially for patients with diagnosed affective disorders as well as individuals from the general population with enhanced depression symptoms.

Following the available research (Camacho et al., 1991; Eime et al., 2013; Velten et al., 2014), physical activity could be a factor that reduces the experience of high psychological burden by Covid-19. In accordance with the recommendations of the World Health Organization, about 30 minutes of cumulative moderate physical activity daily can provide significant health benefits (World Health Organization, 2003). Regularly engagement in activities like jogging, cycling, or swimming not only improves the physical health state, but also fosters mental health (Rebar et al., 2015). It buffers the negative impact of traumatic experiences and daily stressors. Moreover, it can reduce depression symptoms and addictive tendencies (Brailovskaia et al., 2018; Harris et al., 2006). Physical activity can contribute to the experience of positive emotions and enhance the individual level of sense of control, self-efficacy, self-esteem, and positive mental health (Richards et al., 2015). It can also foster the individual resilience level and contribute to adaptive coping strategies in stressful and uncertain situations (McAuley et al., 2000; Wunsch et al., 2017). Considering the presented framework, it can be hypothesized that physical activity may be a significant protective factor in the current Covid-19 situation. Individuals who frequently engage in physical activity could experience less psychological burden by Covid-19. Moreover, physical activity could buffer the association between depression symptoms and experienced burden.

Based on the presented background, the main aim of the current study was to investigate the relationship between depression symptoms,

psychological burden by Covid-19, and physical activity. It was expected that depression symptoms are positively associated with psychological burden by Covid-19 (Hypothesis 1a); physical activity is negatively linked to depression symptoms (Hypothesis 1b) and psychological burden (Hypothesis 1c); and physical activity buffers the link between depression symptoms and psychological burden (Hypothesis 2).

Considering that Covid-19 is a global problem that impacts life in many countries, it is urgent to gain a broad cross-national picture of the burden caused by the pandemic and potential factors that can influence its extent. Therefore, the present study investigated whether similar result patterns occur in samples from four countries where the impact of the pandemic varies in its extent: Germany, Italy, Russia, and Spain (see <https://github.com/owid/covid-19-data/tree/master/public/data>). In all four countries, national lockdowns started in March of 2020 that included bans on gatherings and closing of different establishments; “stay-at-home” was ordered at least in some regions and wearing of face masks in public places is still mandatory (Bundesministerium für Gesundheit, 2020; Ministerio de Sanidad, 2020b; Ministero della Salute, 2020; The Russian Government, 2020).

The hypotheses were examined in the overall sample that includes data from all four countries. Furthermore, in order to identify possible country-specific differences, the hypotheses were examined separately in the respective country samples.

## 2. Methods

### 2.1. Procedure and participants

The overall sample was comprised of 1,931 participants from four countries: Germany: N = 625, Italy: N = 936, Russia: N = 230, and Spain: N = 140. Demographics of the overall sample and of the country-specific samples are shown in Table 1. Data were collected simultaneously in Germany, Italy, Russia, and Spain by means of online surveys

**Table 1**  
Demographic variables and frequency of physical activity (overall and each sample).

	All (N = 1,931)	Germany (N = 625)	Italy (N = 936)	Russia (N = 230)	Spain (N = 140)
Age (M(SD; Min–Max))	26.87 (7.74; 18–77)	27.32 (6.82; 18–71)	24.84 (5.54; 19–70)	29.15 (9.01; 18–61)	34.66 (13.58; 21–77)
Gender (female, %)	77.6	75.7	77.4	87.8	72.1
Marital Status (%)					
Single	43.8	42.7	44.1	46.1	42.9
Romantic relationship, not married	40.8	44.0	42.6	27.8	35.0
Married	15.4	13.3	13.2	26.1	22.1
Occupation (%)					
Student	69.9	64.2	87.1	36.1	35.7
Employee	28.3	34.2	12.0	59.1	60.7
Unemployed	1.8	1.4	1.0	4.8	3.6
Retired	0.1	0.2	0	0	0
Physical Activity (%)					
(0) “Never”	12.8	13.0	12.9	8.3	19.3
(1) “Once a month or less”	13.6	14.9	12.7	15.7	10.7
(2) “Two to four times a month”	22.7	26.2	20.1	29.6	13.6
(3) “Two to three times a week”	34.4	34.4	36.2	29.1	30.7
(4) “Four times a week or more”	16.4	11.5	18.1	17.4	25.7

Notes. M = Mean; SD = Standard Deviation; Min = Minimum; Max = Maximum; due to rounding, the sum of the frequencies is not always 100%.

in the respective national languages of the four countries between late March of 2020 and early September of 2020. At the moment of the data collection, all participants were geographically located in the appropriate country (i.e., German participants were located in Germany, Italian participants were located in Italy, Russian participants were located in Russia, and Spanish participants were located in Spain). This information was provided by a self-declaration at the beginning of the survey. The present study is based on an ad-hoc cooperation project between researchers from the four countries. Due to the Covid-19 situation, the research conditions and possibilities of data collection were different in the individual countries. This explains the different size and composition of the convenience samples and the different methods of recruitment.

In Germany, a participation invitation that included a link leading to the online survey was emailed to overall 700 persons. They all are current or former students of a large university in the Ruhr region and had agreed to be contacted for research investigations when they enrolled at the university. Overall the survey was completed by 98.6% of the 634 individuals who activated the survey link.

In Italy, the link to the survey was sent to all institutional email addresses of the students of the University of Florence together with an invitation to disseminate the link via email or social media among friends and acquaintances. Overall the survey was completed by 98.3% of the 952 individuals who activated the survey link.

In Russia, the link to the online survey was sent to overall 200 professors and student course mentors of a large university in Moscow. The contact details were available from the responsible authorities of the university. All participants were invited to share the link with their colleagues and fellow students. The survey was completed by all individuals who activated the survey link.

In Spain, the study was advertised on different social media (i.e., Facebook, Twitter, Instagram, and WhatsApp). The link to the online survey was included in the advertisement to facilitate the response to the questionnaires. Moreover, the dissemination of the study among friends, co-workers and relatives was encouraged. Overall the survey was completed by 90.9% of the 154 individuals who activated the survey link.

There were no specific requirements for participation, which was voluntary and not compensated in Italy, Russia and Spain. In Germany, participation was compensated by course credits for students. All participants were provided instruction and gave informed consent to participate via an online form. The present study was coordinated in Germany. Therefore, the responsible Ethics Committee of a large university in the German Ruhr region approved the implementation of the international study. Additionally, an approval was received from the Ethics Committee of the University of Florence.

## 2.2. Measures

Psychological burden caused by Covid-19. The experience of burden caused by Covid-19 was assessed with six items (e.g., “I am burdened by the current social situation”, “I feel restricted in my everyday life”, “I feel socially isolated”) that are rated on a 7-point Likert-type scale (1 = I do not agree, 7 = I totally agree; scale reliability: all: Cronbach’s  $\alpha = .654$ ; Germany:  $\alpha = .740$ ; Italy:  $\alpha = .602$ ; Russia:  $\alpha = .773$ ; Spain:  $\alpha = .670$ ). Higher sum scores indicate higher levels of burden.

Frequency of physical activity. The frequency of physical activity was assessed using the item “How frequently did you engage in physical activity (e.g., jogging, cycling) in the last 12 months?” rated on a 5-point Likert-type scale (0 = never, 4 = four times a week or more). Available research described it to be a reliable and valid instrument to measure physical activity (Brailovskaia et al., 2018; Milton et al., 2011).

Depression symptoms. Depression symptoms were assessed with the depression subscale of the Depression Anxiety Stress Scales 21 (DASS-21; Lovibond and Lovibond, 1995). The DASS-21 is an international well-established instrument with good psychometric properties

(Scholten et al., 2017). The seven items (e.g., “I felt that life was meaningless”) are rated on a 4-point Likert-type scale (0 = did not apply to me at all; 3 = applied to me very much or most of the time; scale reliability: all:  $\alpha = .911$ ; Germany:  $\alpha = .885$ ; Italy:  $\alpha = .914$ ; Russia:  $\alpha = .890$ ; Spain:  $\alpha = .895$ ). Higher sum scores indicate higher depression symptoms.

## 2.2. Statistical analyses

Statistical analyses were conducted using SPSS 26 and the macro Process version 3.5 ([www.processmacro.org/index.html](http://www.processmacro.org/index.html); Hayes, 2013). After descriptive analyses, the relationship between psychological burden caused by Covid-19, depression symptoms, and physical activity was assessed by zero-order bivariate correlation analyses. Next, a mediation model was calculated (Process: model 4) that included depression symptoms as predictor, physical activity as mediator, and psychological burden as outcome; age and gender were included as covariates. The relationship between depression symptoms and physical activity was denoted by path a; path b denoted the association between physical activity and psychological burden. The indirect effect (ab) was represented by the combined effect of path a and path b. The basic association between depression symptoms and psychological burden was denoted by path c (the total effect), while the relationship between depression symptoms and psychological burden after the inclusion of physical activity in the model was denoted by path c' (the direct effect). The mediation effect was assessed by the bootstrapping procedure (10,000 samples) that provides percentile bootstrap confidence intervals (CI 95%). Fig. 1 illustrates the model. All calculations were conducted in the overall sample and in each country-specific sample separately. There were no missing data. Power analyses (G\*Power program, version 3.1) revealed that the sample sizes are sufficient for valid results (power  $> .80$ ,  $\alpha = .05$ , effect size:  $f^2 = .15$ ; cf., Mayr et al., 2007).

## 3. Results

Table 1 and 2 present the descriptive statistics of the investigated variables for the overall sample and for each participating country. Furthermore, Table 2 shows the correlations between psychological burden, depression symptoms, and physical activity. The results revealed the same correlation pattern in all samples. Psychological burden was significantly positively correlated with depression symptoms. Physical activity was significantly negatively correlated with psychological burden and depression symptoms (see Table 2).

The mediation analysis also showed the same result pattern in all samples (see Table 3). Physical activity partly mediated the positive relationship between depression symptoms and psychological burden by Covid-19. The basic relationship between depression symptoms (predictor) and psychological burden (outcome) was significant (see Table 3, total effect, c). The association between depression symptoms and physical activity (mediator) (path a: all samples:  $p < .001$ ), and the

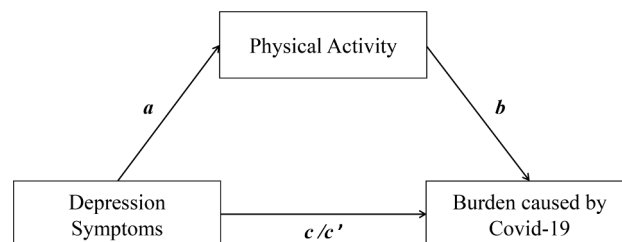


Fig. 1. Mediation model with depression symptoms (predictor), physical activity (mediator), burden caused by Covid-19 (outcome). Notes. c = path of predictor to outcome, without inclusion of mediator (total effect); a = path of predictor to mediator; b = path of mediator to outcome; c' = path of predictor to outcome including mediator (direct effect).

**Table 2**  
Descriptive statistics and correlations of the investigated variables (overall and each sample).

	M (SD)	Min–Max	(2)	(3)
All (N = 1,931)				
(1) Burden by Covid-19	23.47 (6.42)	6–42	.396**	-.183*
(2) Depression Symptoms	6.50 (5.40)	0–21		-.189**
(3) Physical Activity	3.28 (1.25)	1–5		
Germany (N = 625)				
(1) Burden by Covid-19	23.18 (6.26)	6–40	.310**	-.131*
(2) Depression Symptoms	4.50 (4.34)	0–21		-.149**
(3) Physical Activity	3.17 (1.20)	1–5		
Italy (N = 936)				
(1) Burden by Covid-19	23.56 (6.09)	6–41	.408**	-.142**
(2) Depression Symptoms	7.40 (5.45)	0–21		-.200**
(3) Physical Activity	3.34 (1.27)	1–5		
Russia (N = 230)				
(1) Burden by Covid-19	24.68 (7.73)	6–42	.459**	-.287**
(2) Depression Symptoms	9.48 (5.83)	0–21		-.290**
(3) Physical Activity	3.32 (1.17)	1–5		
Spain (N = 140)				
(1) Burden by Covid-19	22.16 (6.59)	9–39	.510**	-.472**
(2) Depression Symptoms	4.44 (4.69)	0–19		-.462**
(3) Physical Activity	3.33 (1.46)	1–5		

Notes. M = Mean; SD = Standard Deviation; Min = Minimum; Max = Maximum; \*\*p < .001; \*p < .01.

relationship between physical activity and psychological burden (path b: Germany and Italy: p < .05, Russia p < .01, Spain: p < .001) were also significant. The association between depression symptoms and psychological burden remained significant after the inclusion of physical activity in the model. However, the total effect was higher than the direct effect (see Table 3, direct effect, c'). The indirect effect was significant (see Table 3, indirect effect, ab).

**4. Discussion**

The level of psychological burden caused by the current Covid-19 situation can impact the individual health state and the willingness to adhere to the governmental measures to fight the pandemic (Brailovskaia and Margraf, 2020b). The present cross-national results revealed two potential factors that can influence the level of psychological burden and explain how they can interact.

As expected, depression symptoms were positively associated with psychological burden caused by Covid-19 (confirmation of Hypothesis 1a). Note, the sudden outbreak of Covid-19 required many people to (partly radically) change their everyday life (Lewnard and Lo, 2020). For instance, planned trips, visits and in-person meetings had to be cancelled. The introduction of measures such as home-schooling and home-office required rapid adaptation of the daily routine and implied

**Table 3**  
Estimated coefficients of the mediation models with depression symptoms (predictor), physical activity (mediator), and burden caused by Covid-19 (outcome) (overall and each sample).

	Total Effect			Direct Effect			Indirect Effect		
	c	SE	95% CI	c'	SE	95% CI	ab	SE	95% CI
All (N = 1,931)									
Burden by Covid-19	.475	.025	[.426, .524]	.449	.025	[.400, .498]	.026	.006	[.016, .038]
Germany (N = 625)									
Burden by Covid-19	.449	.055	[.341, .557]	.427	.055	[.318, .535]	.022	.011	[.003, .047]
Italy (N = 936)									
Burden by Covid-19	.464	.033	[.399, .530]	.450	.034	[.383, .517]	.014	.007	[.001, .029]
Russia (N = 230)									
Burden by Covid-19	.610	.078	[.456, .764]	.543	.080	[.384, .701]	.068	.029	[.019, .132]
Spain (N = 140)									
Burden by Covid-19	.755	.103	[.551, .959]	.560	.111	[.341, .779]	.195	.059	[.091, .322]

Note. SE = standard error; CI = Confidence interval; all CIs generated with bootstrapping: N = 10,000; c = relationship between depression symptoms and burden (total effect); c' = relationship between depression symptoms and burden after inclusion of physical activity in the model (direct effect); ab = combined effect of path a (relationship between depression symptoms and physical activity) and path b (relationship between physical activity and burden).

new obligations (Galea et al., 2020). The requirements are challenging, especially for people with enhanced levels of depression symptoms (Bueno-Notivol et al., 2020). Their low self-efficacy and tendency to ruminate and to worry can contribute to the experience of psychological burden when facing the need to manage the new uncertain Covid-19 situation.

Available literature emphasized that physical activity is an important protective factor of mental and physical health (Vuillemin et al., 2005). It buffers the negative impact of stressful experiences and confers resilience to manage challenges (Brailovskaia et al., 2018; Richards et al., 2015). Correspondingly, in the present study, physical activity was negatively associated with depression symptoms (confirmation of Hypothesis 1b) and psychological burden caused by Covid-19 (confirmation of Hypothesis 1c). Moreover, physical activity buffered the relationship between both variables (confirmation of Hypothesis 2). The present findings can be explained as following. It seems that individuals who regularly engage in physical activity, for example jogging or cycling, experience the current Covid-19 situation as less burdensome. They are more resilient and have more resources to manage and to adapt to the new extraordinary requirements. Following the current results, especially people with enhanced levels of depression symptoms, who are characterized by problems to adapt to new situations (Andrews and Wilding, 2004), can benefit from physical activity. The engagement in physical activity reduces the time of rumination and can contribute to the experience of positive emotions (Rebar et al., 2015) that are often missed by individuals with increased depression symptoms (Freudenstein et al., 2012). Improvement of one's performance and the achievement of small self-imposed physical goals such as an increase in speed when jogging are rewarding and can enhance enjoyment and happiness (Bailey et al., 2013). Moreover, physical activity fosters the individual sense of control and self-efficacy (Eime et al., 2013). Both are urgent to experience the current Covid-19 situation as less burdensome and to manage the new requirements of everyday life (Allington et al., 2020).

The present results from four countries emphasize that while depression symptoms may be a significant risk factor that fosters the experience of psychological burden caused by Covid-19, physical activity can contribute to less burden experience and a more adaptive response to the current situation. The protective effect of physical activity can be used to buffer the negative impact of enhanced depression symptoms. Considering that the global course of the pandemic remains unclear, it is important for governments and authorities to consider present findings when working on specific steps to longitudinally protect mental and physical health during the pandemic. Public governmental communication should explicitly address the positive effect of physical activity especially for individuals with enhanced levels of depression symptoms and encourage the participation in the activities. It should be emphasized that physical activity does not necessarily imply competitive

sport or the use of specific expensive equipment. Everyone can perform physical activity in the own rhythm and according to the own physical conditions at home or outdoors (Eime et al., 2013).

Despite the timeliness of the present study, the following limitations should be taken into account. First, due to the cross-sectional design, only hypothetical causality considerations are possible. Therefore, future studies are suggested to replicate the present findings by using a longitudinal experimental design that includes several measurement time points, and for instance the manipulation of the potential buffer (physical activity). Second, the mostly female and rather young composition of the convenience samples limits the generalizability of the current findings. Note that women are at a higher risk than men to develop depression symptoms (Parker and Brotchie, 2010). Moreover, recent research described a significant increase of depression symptoms specifically in adolescents and young adults in the last years (Brailovskaia and Margraf, 2020a; Twenge et al., 2019). Against this background, it can be assumed that the found protective effect is especially relevant for young female individuals. However, the present findings should not be overstated because the composition of the investigated samples does not allow gender- and age-related conclusions. To partly tackle this limitation, gender and age were included as control variables in the mediation analysis. Nonetheless, the present samples are convenience. Therefore, the current findings should be interpreted with caution. Their replication in population representative samples is desirable. Third, due to the Covid-19 situation, the research conditions and possibilities differed between the four countries. This resulted in varied samples sizes. Specifically, the samples in Spain and Russia are remarkably smaller than the samples in Italy and Germany. Interestingly, the largest buffering effect of physical activity was found in Spain, followed by Russia. The smallest effect was found in Italy, followed by Germany (see Table 3). A possible explanation for the largest effect in Spain and Russia may be at least partly related to the similarities of the strict confinement Covid-19 measures introduced in both countries. It can be assumed that the strict limitations for engaging in physical activity during the confinement (i.e., the impossibility of engaging in outdoor activities such as jogging) limited to a greater extent individuals with enhanced depression symptoms who are characterized by an inability to adapt to new uncertain situations. This could reinforce the negative relationship between depression symptoms and physical activity, and consequently, the negative relationship between physical activity and psychological burden. On the contrary, individuals with lower depression symptoms could be rather able to find ways to engage in indoor physical activity and therefore to reduce the psychological burden caused by the Covid-19 situation. The small effect in Italy might be at least partly due to the low reliability of the psychological burden measure in this country. Fourth, in order not to overload the participants, only self-reported frequency of physical activity in the last twelve months was assessed. Earlier research reported this 1-Item instrument to be a reliable and valid measure (Milton et al., 2011). Nevertheless, in order to obtain a more comprehensive picture of physical activity as buffer between depression symptoms and psychological burden caused by Covid-19, future studies should include further (more objective) measures of physical activity (e.g., exact daily time spent on physical activity, which activity is performed and its power level). Furthermore, future longitudinal research is suggested to assess potential changes of the frequency of physical activity since the beginning of the pandemic and the lockdowns introduced to reduce its spread. Fifth, the mediation analysis revealed a partial mediation effect in all samples. Future studies should investigate further factors than can buffer the association between depression symptoms and burden caused by Covid-19, such as for instance sense of control, self-efficacy, and perceived social support (e.g., Gorday et al., 2018; Lei et al., 2016). Sixth, the main focus of the present study was on psychological burden that implies a strong feeling of being generally overwhelmed by the Covid-19 situation. However, burden can also be associated with specific domains (e.g., home, work, financial, health). The importance of such domains can interpersonally

differ. Negative events in domains that are of specific importance for the individual are experienced as more burdensome and have a stronger impact on mental and physical health than negative events in less important domains (Keyes et al., 2002). Therefore, future research is suggested to assess more specifically the domains of the burden and their individual relevance. Additionally, even though similar result patterns were found in the overall sample and in the country-specific samples, individual culture and country-specific interpretation differences considering the meaning of burden cannot be excluded.

To conclude, it is still unclear how long and to which extent the pandemic will spread around the globe. Knowledge gained by the present findings can contribute to the development of programs to reduce negative consequences of Covid-19 for mental health and physical health, and to strengthen an adaptive response and adherence to the introduced measures. The present cross-national study shows that across four countries (Germany, Italy, Russia, and Spain), individuals with enhanced depression symptoms are at risk to experience psychological burden by the current Covid-19 situation. However, physical activity can buffer this negative effect. This issue should be addressed in governmental steps of health protection to successfully manage the Covid-19 pandemic and its longitudinal consequences.

### Contributors

All authors read and approved the final manuscript. Julia Brailovskaia, Fiammetta Cosci, Giovanni Mansueto, Marta Miragall, Rocío Herrero, Rosa M. Baños, Yulia Krasavtseva, Yakov Kochetkov, and Jürgen Margraf conducted the study design. Julia Brailovskaia, Fiammetta Cosci, Giovanni Mansueto, Marta Miragall, Rocío Herrero, Rosa M. Baños, and Yulia Krasavtseva conducted the data collection and data preparation. Julia Brailovskaia conducted the statistical analysis and wrote the lead of the article. All authors reviewed and edited the final version of the article. All authors state their compliance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

### Role of the funding source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

### Declarations of Competing Interest

none

### Acknowledgments

None.

### References

- Allington, D., Duffy, B., Wessely, S., Dhavan, N., Rubin, J., 2020. Health-protective behavior, social media usage and conspiracy belief during the COVID-19 public health emergency. *Psychol. Med* 1–7. <https://doi.org/10.1017/S003329172000224X>.
- Andrews, B., Wilding, J.M., 2004. The relation of depression and anxiety to life-stress and achievement in students. *Brit. J. Psychol.* 95 (4), 509–521. <https://doi.org/10.1348/0007126042369802>.
- Bailey, R., Hillman, C., Arent, S., Petitpas, A., 2013. Physical activity: an underestimated investment in human capital? *J. J. Phy. Activ. Health* 10, 289–308. <https://doi.org/10.1123/jpah.10.3.289>.
- Brailovskaia, J., Margraf, J., 2020a. Decrease of well-being and increase of online media use: cohort trends in German university freshmen between 2016 and 2019. *Psychiatry Res.* 290, 113110. <https://doi.org/10.1016/j.psychres.2020.113110>.
- Brailovskaia, J., Margraf, J., 2020b. Predicting adaptive and maladaptive responses to the Coronavirus (COVID-19) outbreak: a prospective longitudinal study. *Int. J. Clin. Health Psychol.* 20 (3) <https://doi.org/10.1016/j.ijchp.2020.06.002>, 1831–1191.
- Brailovskaia, J., Teismann, T., Margraf, J., 2018. Physical activity mediates the association between daily stress and facebook addiction disorder (FAD) – a longitudinal approach among German students. *Comput. Human Behav.* 86, 199–204. <https://doi.org/10.1016/j.chb.2018.04.045>.

- Bueno-Notivol, J., Gracia-García, P., Olaya, B., Lasheras, I., López-Antón, R., Santabàrbara, J., 2020. Prevalence of depression during the COVID-19 outbreak: a meta-analysis of community-based studies. *Int. J. Clin. Health Psychol.* <https://doi.org/10.1016/j.ijchp.2020.07.007>.
- Bundesministerium für Gesundheit, 2020. Coronavirus SARS-CoV-2: Chronik der bisherigen Maßnahmen. Retrieved from <https://www.bundesgesundheitsministerium.de/coronavirus/chronik-coronavirus.html>.
- Buysse, D.J., Angst, J., Gamma, A., Ajdacic, V., Eich, D., Rössler, W., 2008. Prevalence, course, and comorbidity of insomnia and depression in young adults. *Sleep* 31 (4), 473–480.
- Camacho, T.C., Roberts, R.E., Lazarus, N.B., Kaplan, G.A., Cohen, R.D., 1991. Physical activity and depression: evidence from the alameda county study. *Am. J. Epidemiol.* 134 (2), 220–231. <https://doi.org/10.1093/oxfordjournals.aje.a116074>.
- Eime, R.M., Young, J.A., Harvey, J.T., Charity, M.J., Payne, W.R., 2013. A systematic review of the psychological and social benefits of participation in sport for adults: informing development of a conceptual model of health through sport. *Int. J. Behav. Nutr. Phys. Act.* 10 (1), 135–148. <https://doi.org/10.1186/1479-5868-10-135>.
- Freudenstein, O., Valevski, A., Apter, A., Zohar, A., Shoval, G., Nahshoni, E., Weizman, A., Zalsman, G., 2012. Perfectionism, narcissism, and depression in suicidal and nonsuicidal adolescent inpatients. *Compr. Psychiatry* 53 (6), 746–752.
- Galea, S., Merchant, R.M., Lurie, N., 2020. The mental health consequences of COVID-19 and physical distancing: the need for prevention and early intervention. *JAMA Intern. Med.* 180 (6), 817–818. <https://doi.org/10.1001/jamainternmed.2020.1562>.
- Gandhi, M., Rutherford, G.W., 2020. Facial masking for covid-19—potential for “Variolation” as we await a vaccine. *New Eng. J. Med.* <https://doi.org/10.1056/NEJMp2026913>.
- Gorday, J.Y., Rogers, M.L., Joiner, T.E., 2018. Examining characteristics of worry in relation to depression, anxiety, and suicidal ideation and attempts. *J. Psychiatr. Res.* 107, 97–103. <https://doi.org/10.1016/j.jpsychires.2018.10.004>.
- Harris, A.H.S., Cronkite, R., Moos, R., 2006. Physical activity, exercise coping, and depression in a 10-year cohort study of depressed patients. *J. Affect. Disord.* 93 (1–3), 79–85. <https://doi.org/10.1016/j.jad.2006.02.013>.
- Hayes, A.F., 2013. Introduction to mediation, moderation, and conditional process analysis. Guilford Press, London.
- Keyes, C.L., Shmotkin, D., Ryff, C.D., 2002. Optimizing well-being: the empirical encounter of two traditions. *J. Pers. Soc. Psychol.* 82 (6), 1007–1022.
- Lei, X.-Y., Xiao, L.-M., Liu, Y.-N., Li, Y.-M., 2016. Prevalence of depression among Chinese university students: a meta-analysis. *PLoS One* 11 (4), e0153454. <https://doi.org/10.1371/journal.pone.0153454>.
- Lewnard, J.A., Lo, N.C., 2020. Scientific and ethical basis for social-distancing interventions against COVID-19. *Lancet. Dis.* 20 (6), 631–633. [https://doi.org/10.1016/S1473-3099\(20\)30190-0](https://doi.org/10.1016/S1473-3099(20)30190-0).
- Lovibond, S.H., Lovibond, P.F., 1995. *Manual for the Depression Anxiety Stress Scales, 2nd ed.* Psychology Foundation, Sydney.
- Mayr, S., Erdfelder, E., Buchner, A., Faul, F., 2007. A short tutorial of GPower. *Tutor. Quantit. Methods Psychol.* 3 (2), 51–59. <https://doi.org/10.20982/tqmp.03.2.p051>.
- McAuley, E., Blissmer, B., Katula, J., Duncan, T.E., Mihalko, S.L., 2000. Physical activity, self-esteem, and self-efficacy relationships in older adults: a randomized controlled trial. *Ann. Behav. Med.* 22 (2), 131. <https://doi.org/10.1007/BF02895777>.
- Milton, K., Bull, F.C., Bauman, A., 2011. Reliability and validity testing of a single-item physical activity measure. *Br. J. Sports Med.* 45 (3), 203–208. <https://doi.org/10.1136/bjism.2009.068395>.
- Ministerio de Sanidad, 2020b. Acuerdo del consejo interterritorial del Sistema Nacional de Salud del 14 de agosto. Retrieved from <https://cpm.es/wp-content/uploads/2020/08/acuerdo-del-consejo-interterritorial-del-sistema-nacional-de-salud-14-agosto-2020.pdf>.
- Ministero della Salute, 2020. Novel coronavirus. Daily situation report. Retrieved from <http://www.salute.gov.it/portale/nuovocoronavirus/homeNuovoCoronavirus.jsp>.
- Parker, G., Brotchie, H., 2010. Gender differences in depression. *Int. Rev. Psychiatry* 22 (5), 429–436. <https://doi.org/10.1136/bjpsports-2015-095756>.
- Rebar, A.L., Stanton, R., Geard, D., Short, C., Duncan, M.J., Vandelandotte, C., 2015. A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychol. Rev.* 9 (3), 366–378. <https://doi.org/10.1080/17437199.2015.1022901>.
- Richards, J., Jiang, X., Kelly, P., Chau, J., Bauman, A., Ding, D., 2015. Don't worry, be happy: cross-sectional associations between physical activity and happiness in 15 European countries. *BMC Pub. Health* 15 (1), 53. <https://doi.org/10.1186/s12889-015-1391-4>.
- Scholten, S., Velten, J., Bieda, A., Zhang, X.C., Margraf, J., 2017. Testing measurement invariance of the depression, anxiety, and stress scales (DASS-21) across four countries. *Psychol. Assess.* 29 (11), 1376–1390. <https://doi.org/10.1037/pas0000440>.
- Schönfeld, P., Brailovskaia, J., Bieda, A., Zhang, X.C., Margraf, J., 2016. The effects of daily stress on positive and negative mental health: mediation through self-efficacy. *Int. J. Clin. Health Psychol.* 16 (1), 1–10. <https://doi.org/10.1016/j.ijchp.2015.08.005>.
- Sohrabi, C., Alsafi, Z., O'Neill, N., Khan, M., Kerwan, A., Al-Jabir, A., Iosifidis, C., Agha, R., 2020. World Health Organization declares global emergency: a review of the 2019 novel coronavirus (COVID-19). *Int. J. Surg.* 76, 71–76. <https://doi.org/10.1016/j.ijsu.2020.02.034>.
- Spasojević, J., Alloy, L.B., 2001. Rumination as a common mechanism relating depressive risk factors to depression. *Emotion* 1 (1), 25. <https://doi.org/10.1037/1528-3542.1.1.25>.
- Taylor, S., Landry, C.A., Paluszek, M.M., Fergus, T.A., McKay, D., Asmundson, G.J.G., 2020. COVID stress syndrome: concept, structure, and correlates. *Dep. Anxiety* 37 (8), 706–714. <https://doi.org/10.1002/da.23071>.
- The Russian Government, 2020. COVID. Retrieved from <http://government.ru/en/search/?q=COVID&dt.till=16.07.2020&dt.since=7.05.2012&sort=rel&type=>.
- Tso, R.V., Cowling, B.J., 2020. Importance of face masks for COVID-19—a call for effective public education. *Clin. Infect. Dis.* <https://doi.org/10.1093/cid/ciaa593>.
- Twenge, J.M., Cooper, A.B., Joiner, T.E., Duffy, M.E., Binau, S.G., 2019. Age, period, and cohort trends in mood disorder indicators and suicide-related outcomes in a nationally representative dataset, 2005–2017. *J. Abnorm. Psychol.* 128 (3), 185–199. <https://doi.org/10.1037/abn0000410>.
- Velten, J., Lavallee, K.L., Scholten, S., Meyer, A.H., Zhang, X.-C., Schneider, S., Margraf, J., 2014. Lifestyle choices and mental health: a representative population survey. *BMC Psychol* 2 (1), 58. <https://doi.org/10.1186/240359-014-0055-y>.
- Vuillemin, A., Boini, S., Bertrais, S., Tessier, S., Oppert, J.-M., Hercberg, S., Guillemin, F., Briançon, S., 2005. Leisure time physical activity and health-related quality of life. *Prevent. Med.* 41 (2), 562–569. <https://doi.org/10.1016/j.ypmed.2005.01.006>.
- World Health Organization, 2003. Health and development through physical activity and sport. World Health Organization. Retrieved from [https://apps.who.int/iris/bitstream/handle/10665/67796/WHO\\_NMH\\_NPH\\_PAH\\_03.2.pdf](https://apps.who.int/iris/bitstream/handle/10665/67796/WHO_NMH_NPH_PAH_03.2.pdf).
- World Health Organization, 2020a. Considerations in adjusting public health and social measures in the context of COVID-19. Retrieved from WHO/2019-nCoV/Adjusting\_PH\_measures/2020.1-eng.pdf.
- World Health Organization, 2020b. Coronavirus disease 2019 (COVID-19): Situation Report, 51. World Health Organization. Retrieved from <https://apps.who.int/iris/bitstream/handle/10665/331475/nCoVsitrep11Mar2020-eng.pdf>.
- Wunsch, K., Kasten, N., Fuchs, R., 2017. The effect of physical activity on sleep quality, well-being, and affect in academic stress periods. *Nature and science of sleep* 9, 117–126. <https://doi.org/10.2147/NSS.S132078>.