LONG-TERM CONSEQUENCES OF COVID-19 ON MENTAL AND PHYSICAL HEALTH IN YOUNG ADULTS

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SUMMARY

Objectives: This study investigates the impact of COVID-19 on various long-term psychological and physical symptoms in young adults from Slovakia.

Methods: We assessed 229 Slovak young adults aged 18 to 30 years. Probands were interviewed using standardised questionnaires. The relationship between COVID-19 and long-term health symptoms was determined using Pearson's chi-square test. The McNemar test was used to determine the differences in health symptoms before and after COVID-19 recovery.

Results: The statistically significant effect of COVID-19 after recovery on adverse cognitive health was only documented in women in the following symptoms: memory deterioration ($p < 0.001$), problems with concentration ($p < 0.001$), difficulty in handling tasks requiring thinking, planning and problem-solving ($p < 0.001$), and problems with finding the correct words in their expressions ($p = 0.001$). The prevalence of these symptoms was higher in women after the COVID-19 recovery than before. Participants also reported the most pronounced long-term changes in the following physiological symptoms: decreased physical fitness ($p < 0.001$ for women and men) and headaches ($p < 0.001$ for women). In addition, women menstrual cycle changes were reported significantly more frequently in women after COVID-19 recovery than before ($p < 0.001$). Furthermore, it was found that in addition to overcoming COVID-19, physical inactivity was also significantly associated with a deterioration in memory ($p = 0.042$), concentration problems ($p = 0.041$), and decreased physical fitness in women ($p = 0.014$). Smoking was associated with changes in the menstrual cycle ($p = 0.002$).

Conclusions: Significant effects of COVID-19 on mental and physical health were found. These effects demonstrate that COVID-19 has had a negative impact on the long-term health and quality of life of young adults.

Key words: pandemic, cognitive health, physical fitness, young adults, SARS-CoV-2 infection

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INTRODUCTION

The emergence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) COVID-19 in China at the end of 2019 led to a widespread outbreak and a major public health concern (1). In March 2020, the World Health Organisation (WHO) declared the SARS-Cov-2 virus outbreak a global pandemic. By November 2023, COVID-19 had caused over 772 million confirmed cases and 6.9 million deaths worldwide. In Slovakia, there were 1,868,472 confirmed COVID-19 cases and 21,167 deaths from 3 January 2020 to November 2023 (2). The virus penetrates the nasal and laryngeal mucosa and enters the lungs via the respiratory tract. The symptoms and complications associated with COVID-19 vary from person to person (3).

SARS-CoV-2 infection is known to have a classic respiratory virus-like clinical manifestation, with more than 80% of patients experiencing a mild to severe and self-limiting infection (4). Although most patients recover from acute COVID-19 infection, some experience long-lasting symptoms, which the WHO refers to as "long COVID", "post-COVID syndrome" or "post-COVID-19 condition" (5). Recent data suggest that COVID-19 infection is associated with confusion, depression, fatigue, insomnia, and anxiety. The severity of systemic inflammation during acute infection has been shown to be proportional to the severity of psychiatric symptoms after clearance of the virus and has a negative impact on quality of life after recovery from COVID-19 (6).

In addition, lockdown and physical distancing may have impacted some young people differently depending on their age, sex, ethnicity, family circumstances, socioeconomic situation, and pre-existing mental health problems (7). Young adults (i.e., individuals aged approximately 18 to 30 years) may be particularly vulnerable to such social disorders (8), as young adulthood is a critical developmental period that involves significant changes in all aspects of life (9) and is often characterised by psychiatric disorders (10). In addition, prolonged isolation at home leads to more sedentary behaviour and less physical activity, which can exacerbate mental distress (11). These then contribute to post-COVID-19 symptoms, which can subsequently affect the respiratory, immune, cardiovascular, gastrointestinal, and central nervous systems (12).

Due to the large number of people infected with COVID-19, post-COVID-19 syndrome has become a major public health challenge worldwide. Therefore, in this pilot study, we investigated the impact of COVID-19 on various long-term psychological and physical symptoms in young adults from Slovakia.

MATERIALS AND METHODS

Participants

This study is based on data collected as part of a cross-sectional survey in Slovakia to analyse the impact of COVID-19 disease and the pandemic on the health of young adults. Our sample included 229 young adult Slovak university students and graduates aged 18 to 30 years with an average age of 20.72 ± 2.04 years. The women and men were recruited by non-random volunteer and convenience procedure. They were personally evaluated and interviewed by experienced investigators in the biomedical laboratory of the Department of Anthropology at Comenius University in Bratislava, Slovakia. The interview ensured understanding of the questionnaire and easy processing of the information. The data was collected between September 2021 and November 2022 during the pandemic. Inclusion criteria were participants aged 18 to 30 years and only those infected with the different variants of the SARS-CoV-2 coronavirus that prevailed from March 2020 to November 2022 and verified by RT-PCR or antigen test were included in the study. Vaccinated participants were also included in the study, and for the purposes of this study no differences between mRNA vaccines (Pfizer/BioNTech and Moderna) and viral vector-based vaccines (AstraZeneca and Janssen) were considered. On the other hand, participants recovering from acute disorders were excluded from the survey. Only those who met the above inclusion criteria were included in the study sample. The data were collected in a favourable epidemiological situation, during the period when COVID-19 restrictions, such as lockdown, were lifted. At the time of data collection, study participants had no acute respiratory symptoms of COVID-19 and had negative COVID-19 test results. For the purposes of this study, we defined long-term consequences of COVID-19 as persistence of symptoms or the development of sequelae beyond 4 or more weeks from the onset of acute symptoms. In our sample, the majority of participants (69.87%) experienced these long-term symptoms beyond 3 months from the onset of acute symptoms of COVID-19, and the majority of women and men had a mild or moderate course of the disease, with 98.38% of women and 100% of men.

Each participant provided written informed consent for this study which adhered to the Declaration of Helsinki principles. It was made clear to all young people that participation in the study was entirely voluntary and that they could end the questionnaire at any point if they felt distressed or uncomfortable. The biomedical research was also approved by the Ethics Committee of the Faculty of Natural Sciences at Comenius University, No. ECH19021.

Questionnaire

Initially, the study was conducted using a standardised and validated questionnaire (modified WHO expert questionnaire from 2014 – STEPwise approach to surveillance – instrument v. 3.2 in the Slovak version). This was used to collect information on the baseline characteristics of the study participants and their socio-demographic background. The following lifestyle variables were obtained by self-reporting and personal interview: smoking was categorized as regular smoker or non-smoker; physical activity was assessed by "Do you exercise or practise physical activity?", and the answers were categorized in "yes" and "no" groups.

Self-reported medical characteristics were then recorded in a second questionnaire, including the month and year of COVID-19 onset and the number of COVID-19 diseases overcome. Respondents were then asked: "Did you have the following long-term health problems before and after recovering from COVID-19? (yes/no)" and the following psychological and physical symptoms were analysed: memory deterioration, difficulty in handling tasks requiring thinking, planning and problem solving, concentration problems, problems with finding the correct words in their expressions, depression, anxiety, decreased physical fitness, headaches, cardiovascular problems, lung disease, food intolerances, gastrointestinal diseases, and changes in the menstrual cycle.

Anthropometric Measurements

The anthropometric measurements were carried out by trained anthropologists using standard anthropometric techniques. Height and weight were measured with participants standing without shoes and heavy outer garments. Height was measured using a Sieber and Hegner anthropometer with an accuracy of 0.5 cm, with the participant standing barefoot and with feet together. The body weight was then measured on a personal balance scale with 0.1 kg accuracy. Body mass index (BMI) was calculated as body weight in kilogrammes divided by height squared.

Statistical Analysis

Statistical analyses were performed by IBM SPSS for Windows (Statistical Package for the Social Science, version 25.0, Chicago, IL) and statistical significance was defined as $p \leq 0.05$. A one sample Kolmogorov-Smirnov test assessed the normality assumption hypothesis for continuous variables. The descriptive statistics of frequency and percentages examined participants' responses. The sex differences in category variables were tested by Pearson's chi-square in contingency tables. The non-parametric Mann-Whitney U-test was used to analyse differences in BMI between sexes. The McNemar test with Edwards correction then established the proportion of participants who differed in physiological and psychological symptoms before and after disease recovery. Furthermore, due to reduce the increased risk of a type I error, the Bonferroni correction ($p < 0.05/n$) was used by multiplying the p-value by the number of comparisons. In addition, the environmental characteristics were included as covariates in general linear model repeated measures (GLMr), and these comprised BMI, smoking, and physical activity.

RESULTS

Table 1 summarises baseline descriptions of the proband age, the number of COVID-19 overcoming, the number of asymptomatic disease manifestations and selected environmental fac-

Table 1. *Baseline characteristics of participants (N = 229)*

	Total n (%)	Women n (%)	Men n (%)	p-value
	229	188 (82.16)	41 (17.94)	0.110
Age (years), mean (SD)	20.72 (2.04)	20.59 (1.98)	21.34 (2.23)	
Overcoming COVID-19				
Once	183 (79.91)	150 (79.79)	33 (80.49)	0.919
Twice	38 (16.60)	31 (16.49)	7 (17.07)	
Three times	8 (3.49)	7 (3.72)	1 (2.44)	
Asymptomatic COVID-19				
Yes	16 (6.99)	10 (5.32)	6 (14.63)	**0.034**
No	213 (93.01)	178 (94.68)	35 (85.37)	
Smoking status				
Regular smokers	49 (21.40)	37 (19.70)	12 (29.30)	0.175
Non-smokers	180 (78.60)	151 (80.30)	29 (70.70)	
Physical activity				
Yes	207 (90.39)	171 (90.96)	36 (87.81)	0.501
No	22 (9.61)	17 (9.04)	5 (12.19)	
BMI, mean (SD)	22.38 (4.14)	21.97 (3.67)	24.27 (5.48)	**0.012**

SD – standard deviations
Numbers in bold indicate statistically significant values.

tors. The mean age of the women and men groups did not differ significantly at p = 0.110, 20.59 ± 1.98 years and 21.34 ± 2.23 years, respectively. The majority of studied women (79.79%) and men (80.49%) had COVID-19 once, and only 5.32% of women and 14.63% of men had asymptomatic COVID-19. Among the participants, 21.40% were regular smokers, while 78.60% were non-smokers. Smoking prevalence was significantly higher during the pandemic than before at 21.8% to 15.5% and p = 0.023 (data not shown). In the behavioural components, only 9.61% of participants stated that they were regularly physically active. There was significant difference in BMI between sexes (p = 0.012).

Table 2 shows the percentage of young people who reported various psychological symptoms before and after COVID-19 recovery. We found a significantly higher percentage of women who reported negative psychological changes after COVID-19 recovery, particularly deterioration in memory (16.84% vs. 5.26%, p < 0.001), difficulties in handling tasks requiring thinking, planning and problem solving (16.84% vs. 8.42%, p < 0.001),

Table 2. *Psychological symptoms before and after recovering from COVID-19*

Psychological symptoms		n	Before COVID-19 (%)	95% CI	After COVID-19 (%)	95% CI	χ^2	p-value	Adjusted p-value*
Memory deterioration	Women	188	5.26	0.021–0.085	16.84	0.115–0.222	18.38	**< 0.001**	**< 0.001***
	Men	41	4.87	0.000–0.115	9.75	0.007–0.189	0.50	0.480	1.000
Difficulty in handling tasks requiring thinking, planning, and problem-solving	Women	188	8.42	0.045–0.124	16.84	0.115–0.222	12.50	**< 0.001**	**< 0.001***
	Men	41	9.75	0.007–0.189	17.07	0.056–0.286	0.80	0.371	1.000
Problems with concentration	Women	188	19.47	0.138–0.251	30.52	0.239–0.371	14.82	**< 0.001**	**< 0.001***
	Men	41	14.63	0.038–0.255	21.95	0.092–0.347	1.33	0.248	1.000
Problems with finding the right words during expression	Women	188	8.42	0.045–0.124	15.78	0.106–0.210	10.56	**0.001**	**0.012***
	Men	41	14.63	0.038–0.255	17.07	0.056–0.286	N.A.	N.A.	N.A.
Depression	Women	188	8.42	0.045–0.124	11.05	0.066–0.155	2.27	0.132	1.000
	Men	41	9.75	0.007–0.189	12.19	0.0212–0.223	0.33	0.564	1.000
Anxiety	Women	188	22.10	0.162–0.280	25.26	0.191–0.315	2.57	0.109	1.000
	Men	41	14.63	0.038–0.255	17.07	0.056–0.286	0.20	0.655	1.000

CI – confidence interval; χ^2 – chi-squared distribution with 1 degree of freedom; p – statistically significant value of McNemar's test with Edwards correction; N.A. – not applicable
Numbers in bold indicate statistically significant values. *Statistically significant difference – Bonferroni correction.

Table 3. *Physical symptoms before and after recovering from COVID-19*

Physical symptoms		n	Before COVID-19 (%)	95% CI	After COVID-19 (%)	95% CI	χ^2	p-value	Adjusted p-value*
Decreased physical fitness	Women	188	6.31	0.028–0.098	41.05	0.340–0.481	62.23	**<0.001**	**<0.001***
	Men	41	2.43	0.000–0.072	34.14	0.196–0.487	13.00	**<0.001**	**<0.001***
Headaches	Women	188	19.47	0.138–0.251	32.10	0.255–0.388	20.35	**<0.001**	**<0.001***
	Men	41	9.75	0.007–0.189	17.07	0.056–0.286	1.33	0.250	1.000
Cardiovascular problems	Women	188	5.26	0.021–0.085	6.84	0.032–0.105	0.80	0.371	1.000
	Men	41	2.43	0.000–0.072	2.43	0.000–0.072	N.A.	N.A.	N.A.
Lung diseases	Women	188	1.57	0.000–0.033	2.63	0.003–0.050	0.25	0.617	1.000
	Men	41	0.00	0.000–0.061	2.43	0.000–0.072	N.A.	N.A.	N.A.
Food intolerance	Women	188	14.73	0.097–0.198	16.84	0.115–0.222	1.13	0.289	1.000
	Men	41	2.43	0.000–0.072	4.87	0.000–0.115	N.A.	N.A.	N.A.
Gastrointestinal tract diseases	Women	188	3.68	0.010–0.064	6.84	0.032–0.105	4.17	**0.041**	0.533
	Men	41	2.43	0.000–0.072	4.87	0.000–0.115	N.A.	N.A.	N.A.
Menstrual cycle changes	Women	188	4.73	0.017–0.078	13.68	0.088–0.186	11.13	**<0.001**	**<0.001***

CI – confidence interval; χ^2 – chi-squared distribution with 1 degree of freedom; p – statistically significant value of McNemar's test with Edwards correction; N.A. – not applicable
Numbers in bold indicate statistically significant values. *Statistically significant difference – Bonferroni correction.

concentration problems (30.52% vs. 19.47%, $p<0.001$), and problems finding the correct words during expression (15.78% vs. 8.42%, $p=0.001$). In addition, we recorded a higher frequency of depression and anxiety after overcoming the disease than before, but the results were not statistically significant (11.05% vs. 8.42%, $p=0.135$; 25.26% vs. 22.10%, $p=0.109$, respectively). In contrast, the group of men showed no statistically significant differences in all psychological symptoms before and after COVID-19 recovery.

The proportion of those who reported physiological symptoms before and after COVID-19 recovery is summarised in Table 3. Our analysis found the greatest changes in long-term decreased physical fitness (women: 41.05% vs. 6.31%, $p<0.001$; men: 34.14% vs. 2.43%, $p<0.001$). In addition, the women's group noted an altered prevalence of headaches (32.10% vs. 19.47%, $p<0.001$), gastrointestinal tract diseases (6.84% vs. 3.68%, $p=0.041$), and menstrual cycle changes (13.68% vs. 4.73%, $p<0.001$) after COVID-19 recovery. After adjusting the p-value with the Bonferroni correction, differences remained significant except for gastrointestinal tract diseases in women, as shown in Tables 2 and 3. Furthermore, the GLMr analysis tested the associations of selected environmental factors, specifically BMI, smoking and physical activity, with psychological and physical symptoms. It was found that in addition to overcoming COVID-19, physical inactivity was also significantly associated with a deterioration in memory ($p=0.042$), concentration problems ($p=0.041$), and decreased physical fitness ($p=0.014$) in women. Moreover, smoking was associated with changes in the menstrual cycle in women ($p=0.002$, data not shown).

DISCUSSION

In our study, we analysed the subjective health problems of all participants before and after the outbreak of the disease to determine the long-term effects of COVID-19. The probands reported the most pronounced long-term changes in the following symptoms: reduced physical fitness and headaches. Our results highlighted that both women and men experienced slightly more anxiety and depression after overcoming the disease than before, but this was not statistically significant.

Subsequently, we found a statistically significant decrease in mental symptoms after COVID-19 in women, namely in the following symptoms: memory deterioration, concentration problems, difficulties in handling tasks requiring thinking, planning and problem solving, and in finding the correct words for their expressions. Psychological symptoms were also reported more frequently in our men cohort after the illness, but the symptoms were not statistically significant. We therefore hypothesise that the statistical significance differences indicate that COVID-19 poses a greater threat to women's mental health than men's mental health.

To the best of our knowledge, there are only a few studies on the long-term mental health effects of COVID-19 in young adults aged 18 to 30 years. The first studies mainly focused on the global effects on mental health and found that anxiety and depression increased in both children and adults after the COVID-19 pandemic and that this was particularly noticeable in women (13). Charles et al. (14) added that young adults appeared to be less susceptible to the most severe medical complications associated with COVID-19, but still experienced psychological effects of the pandemic. Widespread research later identified persistent physical and psychological COVID-19 symptoms. These included coughing, shortness of breath, muscle weakness, fatigue, chest and joint pain, as well as memory and concentration difficulties (15). Munblit et al. (16) also reported that almost half of the adults tested who were hospitalised for COVID-19 treatment continued to report symptoms 6 to 8 months after discharge. Again, women predominated, with respiratory problems such as shortness of breath, fatigue and forgetfulness being the most commonly reported symptoms. These findings led to the definition of the new

disease "long post-COVID syndrome" (17). In study of Sedat et al. (18) found that among all participants, a history of COVID-19 infection was identified as a risk factor for developing mental fatigue. Furthermore, Roever et al. (19) indicated that COVID-19 impacted general mental health and led many not only hospitalized patients to develop cognitive decline, memory impairment, anxiety, sleep alterations, and depressive-like behaviour. Moreover, multiple research studies in several countries have also found that not only COVID-19 diseases but also the pandemic is associated with greater stress levels, depression, anxiety, insomnia, drug misuse, and other mental health challenges among young individuals (20, 21). However, many of these studies did not analyse participants in age cohorts, or they only studied middle-aged and older adults with the severe form of COVID-19 and required hospital treatment. In addition, the recovery time for this older subgroup was generally longer than for young adults with mild or no acute symptoms. Herein, we document that many health symptoms and the "long COVID-19 syndrome" also affect the younger generation. Other authors studied children and adolescents and found that headaches, fatigue, neurological and psychological impairments were the most commonly reported specific long COVID-19 symptoms (22).

Our findings are also consistent with those of Zheng et al. (23), who investigated cognitive domains in a group of patients after COVID-19. The oldest patients had relatively intact cognitive functions, while the youngest patients had the most pronounced and heterogeneous cognitive impairments. The 26–39 years old patients had more difficulties than the older cohort of 50–64 years old in at least one test of the cognitive domains of language, executive functions, processing speed, attention, and verbal short-term memory.

Bechmann et al. (24) support our sex-specific predisposition to prolonged COVID-19. Other research groups also reported that the risk of persistent symptoms was higher in women patients than in men patients previously hospitalised for COVID-19, with women being a predictor of chronic fatigue and symptoms of behavioural and mood disorders (16). Bai et al. (25) recently added that female sex is a risk factor for the development of some long-term post-COVID symptoms, including mood disorders, and this was confirmed in a population-based study in Switzerland, where women were more likely than men to report at least one persistent symptom (26). In addition, we observed a statistically significant decrease in women's physical health, including headaches (from 19.47% to 32.10%) and menstrual cycle changes (from 4.73% to 13.68%). SARS-CoV-2 significantly affected the prevalence and clinical course of pre-existing headache disorders, both through social distancing and various (mainly psychological) pandemic-associated factors that exacerbated the frequency and intensity of headaches. In addition, headache is the most common neurological symptom of SARS-CoV-2 infection and is one of the five most common symptoms overall. Knowledge of long COVID headache is still limited, but there is increasing evidence of the characteristics of this novel disorder, particularly in terms of clinical characteristics, some pathophysiological mechanisms and initial treatment recommendations (27). Up to 13.68% of the women we studied reported long-term menstrual cycle changes after overcoming COVID-19, while only 4.73% recorded these changes before the disease. Similarly, the results of previous studies indicated changes in menstrual volume and cycle length after SARS-CoV-2 infection, with women mainly reporting decreased menstrual volume and a prolonged cycle (28). However, we agree with the findings of Lebar et al. (29) that there are too few studies on this topic to draw firm conclusions and that further research is needed. Our results suggest that these studies should focus on the long-term effects of COVID-19 on menstrual cycle changes in young adult women. We also hypothesise that the more pronounced COVID-19-associated stress and cognitive impairment found in young women in many studies, including ours, may be important factors in the occurrence of negative menstrual changes after recovery. This is supported by Demir et al. (30), who found that women's menstrual cycle changes and anxiety scores increased after recovery from COVID-19.

Our major study strength is that it focuses on the young adult age group, who should have fewer general health problems than older cohorts. On the other hand, the main limitations of our work were that we did not objectively monitor the duration of the problems and participants subjectively assessed whether the symptom persisted or not. These limitations resulting from self-assessment were partially resolved by interviewing each participant in person. However, we recommend that this research be continued with close monitoring of the physical and mental state of the young cohort and the duration of negative cognitive symptoms. Our study was also limited by the sample size and composition, particularly the sex imbalance, which could affect the interpretation of our results. The preponderance of women in the study could confound the results regarding sex differences in the long-term consequences of COVID-19. The associations between sex and long-term COVID-19 symptoms should therefore be further confirmed in a larger population and with longer follow-up. In addition, our study lacks detailed information on factors such as isolation, stress, job loss, death of a loved one, and other variables that may also affect mental and physical health. The evaluation of young adults requires completion, and this will enable us to collect further data and build stronger evidence for the reported results.

CONCLUSION

In conclusion, there was an increase in the incidence of adverse psychological and physical symptoms after COVID-19 recovery. Our study has contributed to a better overview of the current health status and quality of life of young adults after COVID-19 disease. Further studies with a longer follow-up period are needed to fully clarify the natural history of post-COVID-19 disease in young adults.

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Conflicts of Interest
None declared

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Authors' Contributions

DF – study conception, design, manuscript writing; VK – data collection, analysis and interpretation, manuscript writing; RB – statistical analysis, manuscript writing; LV – project and conception, design, data collection, and study performance. All authors read and approved the final version of the manuscript.

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