

General anxiety and depression are associated with the physical activity and social interaction levels

Study in Argentinean university students during the COVID-19 outbreak

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Abstract

This study aimed to investigate the levels of depression and Generalized Anxiety Disorder (GAD) among university students during the COVID-19 pandemic and examine their relationship with physical activity and social interaction. Two groups of university students were surveyed to assess depression, generalized anxiety, physical activity, and social interaction at two different time points during the pandemic. The initial survey was conducted in October/November 2020, following a peak in contagions. A subset of participants was re-surveyed in January 2021 to enable longitudinal analysis. Findings indicated a positive correlation between depression and generalized anxiety among both male and female participants. Moreover, engaging in physical activity for more than two days a week and having longer periods of social interaction were associated with lower levels of depression and anxiety. The second survey revealed a decrease in mental health symptoms among the participants. The study suggests that regular physical activity and avoiding prolonged social isolation can have significant benefits for mental health. The findings emphasize the importance of maintaining an active lifestyle and fostering social connections, particularly during periods of crisis such as the COVID-19 pandemic. These results have implications for promoting mental well-being among university students and could inform the development of targeted interventions to support mental health during similar challenging circumstances.

Keywords: COVID-19; Mental Health; Generalized Anxiety Disorder; Depression; Physical activity; Social interaction

Resum

Aquest estudi pretenia investigar els nivells de depressió i trastorn d'ansietat generalitzada (TAG) entre els estudiants universitaris durant la pandèmia de la CO-

VID-19 i examinar la seva relació amb l'activitat física i la interacció social. Es van enquestar dos grups d'estudiants universitaris per avaluar la depressió, l'ansietat generalitzada, l'activitat física i la interacció social en dos moments diferents durant la pandèmia. L'enquesta inicial es va realitzar a l'octubre/novembre del 2020, després d'un pic de contagis. Un subconjunt de participants es va tornar a enquestar el gener de 2021 per permetre l'anàlisi longitudinal. Els resultats van indicar una correlació positiva entre la depressió i l'ansietat generalitzada tant entre homes com dones. A més, fer activitat física durant més de dos dies a la setmana i tenir períodes més llargs d'interacció social es van associar amb nivells més baixos de depressió i ansietat. La segona enquesta va revelar una disminució dels símptomes de salut mental entre els participants. L'estudi suggereix que l'activitat física regular i evitar l'aïllament social prolongat poden tenir beneficis significatius per a la salut mental. Les troballes subratllen la importància de mantenir un estil de vida actiu i fomentar les connexions socials, especialment durant els períodes de crisi com la pandèmia de la COVID-19. Aquests resultats tenen implicacions per a la promoció del benestar mental entre els estudiants universitaris i podrien informar el desenvolupament d'intervencions específiques per donar suport a la salut mental durant circumstàncies difícils similars.

Paraules clau:

COVID-19; Salut Mental; Desordre d'Ansietat Generalitzada; Depressió; Activitat Física; Interacció social

Resumen

Este estudio tuvo como objetivo investigar los niveles de depresión y Trastorno de Ansiedad Generalizada (TAG) entre estudiantes universitarios durante la pandemia de COVID-19 y examinar su relación con la actividad física y la interacción social. Se encuestó a dos grupos de estudiantes universitarios para evaluar la depresión, la ansiedad generalizada, la actividad física y la interacción social en dos momentos diferentes durante la pandemia. La encuesta inicial se realizó en octubre/noviembre de 2020, luego de un pico de contagios. Se volvió a encuestar a un subconjunto de participantes en enero de 2021 para permitir un análisis longitudinal. Los resultados indicaron una correlación positiva entre la depresión y la ansiedad generalizada entre los participantes masculinos y femeninos. Además, realizar actividad física durante más de dos días a la semana y tener períodos más prolongados de interacción social se asoció con niveles más bajos de depresión y ansiedad. La segunda encuesta reveló una disminución en los síntomas de salud mental entre los participantes. El estudio sugiere que la actividad física regular y evitar el aislamiento social prolongado pueden tener beneficios significativos para la salud mental. Los hallazgos enfatizan la importancia de mantener un estilo de vida activo y fomentar las conexiones sociales, particularmente durante períodos de crisis como la pandemia de COVID-19. Estos resultados tienen implicaciones para promover el bienestar mental entre los estudiantes universitarios y podrían informar el desarrollo de intervenciones específicas para apoyar la salud mental durante circunstancias difíciles similares.

Palabras claves: COVID-19; Salud Mental; Desorden de Ansiedad Generalizada; Depresión; Actividad Física; Interacción social

Introduction

COVID 19 has had a dramatic effect globally. While it is primarily recognized as a respiratory disorder, it is becoming increasingly evident that the pandemic's psychological and social consequences, both direct and indirect, are far-reaching and have the potential to affect mental health in the present and future. Generalized Anxiety Disorder (GAD) is one of the most common mental disorders. Depression is one of the most prevalent and treatable mental disorders and is regularly seen by a wide spectrum of healthcare providers, including mental health professionals. There are many research studies that recorded GAD and depression levels during the COVID-19 pandemic. These levels were reported in studies of the general population from countries as diverse as China, Hong Kong, Greece, Argentina, Cypriot, Ireland, Austria, Germany and the US¹⁻¹⁰. A significant adverse outcome of the COVID-19 pandemic is the increased likelihood of social isolation and loneliness. These two factors are strongly associated with anxiety and depression^{11-13,3,14-17}.

In our country, the government decreed a nationwide lockdown on 18 March 2020¹⁸. These restrictive executive orders were renewed every two weeks according to the epidemiological situation until 7th November when the government decreed the end of the lockdown¹⁹. During this period only essential activities were permitted: essential shops were the only ones allowed to be open and individuals had permission to leave their homes exclusively for demonstrated necessities, such as health reasons, shopping for basic needs and essential work^{18,19}. On 7th November 2020, the total number of confirmed COVID-19 cases in Argentina was 1.236.851 with 33.348 confirmed deaths²⁰.

A recent publication in our country highlighted the sudden environmental impacts on affective states a week after the lockdown, showing its more significant impact on the young population²¹. Here, we are interested in evaluating the levels of GAD and depression at the time of closing the lockdown, after people have gone through almost 8 months of policies that strongly restricted social interaction. We are also interested in focusing the study on the population of university students since there are some inconsistent reports from different countries.

In China, moderate-severe scores are only around 3%¹³ and, at the other extreme, in Bangladesh, moderate-severe anxiety records show a prevalence greater than 80%²². Another study carried out in Germany between March and May 2020, yielded a percentage close to 25% of the population of young people between 18 and 24 years old¹. Owing to the significant variability of these percentages, we decided to carry out the work on university students in our country considering a sample from our university (Internal Group from ITBA) and another from various universities (External Group). Then, after the first survey from Oct-Nov 2020, some participants answered the survey again in January 2021, when the number of infected decreased. Thus, we were able to perform cross-sectional and longitudinal analyses of mental health during specific pandemic periods.

As defined by Marroquin and colleagues¹⁴ the term "social distancing", which could be considered opposite to social interaction, comprises interventions spanning both public and private levels. They included either "personal distancing" behaviours to reduce virus transmission (e.g., avoiding physical contact or proximity with non-household members reducing the use of shared public spaces) or government-imposed stay-at-home policies. Here, we asked the participants about the moment they started interacting with people who were not part of the home environment. That is the moment of the year when they began to meet at social gatherings.

On the other hand, physical activity is defined as any bodily/corporal movement produced by skeletal muscles that results in energy expenditure²⁴. It was reported that walking, moderate, vigorous, and total physical activity levels have been reduced during the COVID-19 pandemic confinements in university students of different countries²⁴. Physical activity is known to aid psychological well-being, and it is a coping strategy during this pandemic. In a recent review, it was concluded that performing physical activity during COVID-19 is associated with less depression and anxiety²⁵. In this work, we survey our university students on the frequency that they perform physical activity, and we contrasted it with the self-perceived levels of anxiety and depression.

Material and Methods

Participants, study design and procedure

Two different groups of university students between 18 and 30 years, residents of Metropolitan Area of Buenos Aires (AMBA), Argentina were recruited to participate in this study during the COVID-19 outbreak: 1- an Internal Group was recruited within the Instituto Tecnológico de Buenos Aires, a Technological University; 2- an External Group, more heterogeneous than the first one, recruited from students of several Universities and careers, through the social media. Using the Google Forms platform, both groups were surveyed with the Generalized Anxiety Disorder-7 (GAD-7) and Patient Health Questionnaire-9 (PHQ-9) tests, as well as a questionnaire regarding the number of days they performed physical activity and the period they started social interaction. Data was collected first in October/November 2020 (from 22nd October 2020 to 7th November 2020; Internal Group, 128 students, 51% women; external group 132 students 53% women) and it was repeated in January 2021 for both groups (from 6th January 2021 to 14th January 2021; Internal Group, 27 students, 62% women; External Group, 47 students, 61% women). The subgroup of students that answered in both periods was used for the longitudinal analysis. The AMBA is a geographical region composed of the Autonomous City of Buenos Aires and multiple political units of the Buenos Aires province, which together compose the most populated urban pole of the country.

Survey structure measures

Participants responded about personal information in the first section of the survey. Both groups of university students informed their name, surname, area of residence ('AMBA' or 'Not AMBA'), age ('18' up to '30'), gender ('man', 'woman' and 'other'), an education level ('undergraduate university' or 'graduated') and another demographic characteristic. Then the survey inquired whether they formed physical activity, the grade of social interaction and perceived levels of anxiety and depression.

Physical Activity

All participants were asked if they performed physical activity during COVID-19 outbreak in the last 14 days prior to the survey and how many times per week they normally did it (from '0' to '7'). Only acti-

vities that lasted at least 15 minutes or more were considered, independently of the physical activity intensity.

Social interaction information

Both groups were asked about the grade of social interaction, that is, when they started to see, in a non-virtual way, people outside their cohabiting group, from 'March 2020' (month when restrictions began in Argentina) up to 'November 2020' in the first data collection and up to 'January 2021' in the second data collection. Data obtained was classified in three categories: Low social interaction (LSI, those people who did not practiced SI for 6 months or more), Medium social interaction (MSI, people who practiced SI between 3 to 5 months), and High social interaction (HSI, those who kept SI for 6 month or more). Virtual ways of interaction were not considered given that all participants declared virtual ways of social interaction from the beginning of the pandemic.

Generalized anxiety symptoms

Generalized anxiety was assessed through the 7-item Generalized Anxiety Disorder Scale²⁶. This test measures symptoms over the last 2 weeks. It has been reported that GAD-7 showed strong reliability and validity in identifying probable DSM-IV generalized anxiety disorder²⁷, and it was used in different populations^{28,29}. Briefly, respondents reported their symptoms using a 4-point Likert rating scale ranging from 0 (not at all) to 3 (almost every day) such that the total score ranges from 0 to 21. Scores of 0–4 are thought to represent minimal anxiety, 5–9 mild anxiety, 10–14 moderate anxiety, and 15–21 severe anxiety. The reliability in this study was: 1_ October/November 2020, $\alpha=0.89$ for Internal Group and $\alpha=0.88$ for External Group; 2_ January 2021, $\alpha=0.71$ and $\alpha=0.88$ for the Internal and External Groups, respectively.

Depression symptoms

Depression was assessed through the Patient Health Questionnaire³⁰. PHQ-9 is a reliable and widely validated measure for detecting depression symptoms³⁰⁻³². Its nine items are based on DSM-IV diagnostic criteria for major depressive disorder²⁷. Briefly, the participants reported their symptoms using a 4-point Likert rating scale ranging from 0 (not at all) to 3 (almost every day) such that the total score ranges from 0 to 27. Scores of 0–4 suggest minimal

depression, 5–9 mild depression, 10–14 moderate depression, 15–19 moderately severe depression, and 20–27 severe depression³¹. In this study reliability was: 1- October/November 2020, $\alpha=0.85$ for the Internal Group and $\alpha=0.74$ for the External Group; 2- January 2021, $\alpha=0.82$ and $\alpha=0.85$ for the Internal and External Groups, respectively).

Ethical Considerations

This study was approved by the Students Department of the Instituto Tecnológico de Buenos Aires, with the consent of The University authorities who felt interested in the psychological impact of the COVID-19 pandemic in the students, to take actions directed to attenuate this impact. Before answering the survey, each participant was provided with an informed consent that had to be approved to participate in the study. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the Helsinki Declaration of 1975, as revised in 2008.

Statistical analysis

All data were analysed using GraphPad Prism® 8.0.1 software. First, we calculated descriptive statistics for the sample, expressed as counts and percenta-

ges (%) for non-continuous variables (men, women), and as means with standard error of the mean (SEM) for continuous variables (GAD-score from GAD-7, Depression score from PHQ-9 and mean day of weekly days of physical activity).

The correlation between GAD and depression during 2020 and 2021 was evaluated in the total population, and for male and female students, using a Spearman correlation analysis between these two mental health parameters. To assess the influence of gender and physical activity on states of GAD and Depression on both populations, a series of paired sample tests (Wilcoxon test) (2020 vs 2021) were conducted.

In all cases, the differences between physical activity days per week were evaluated conducting a one-tailed Mann-Whitney analysis. For all the analysis, the differences were considered significant when $p < 0.05$ ($\alpha=0.05$).

Results

Our results show that the self-perceived levels of depression registered in October-November 2020 (from now on 2020) positively correlated with those of GAD in both genders and in both groups of students (Fig 1 A-F). The percentage of people with either moderate

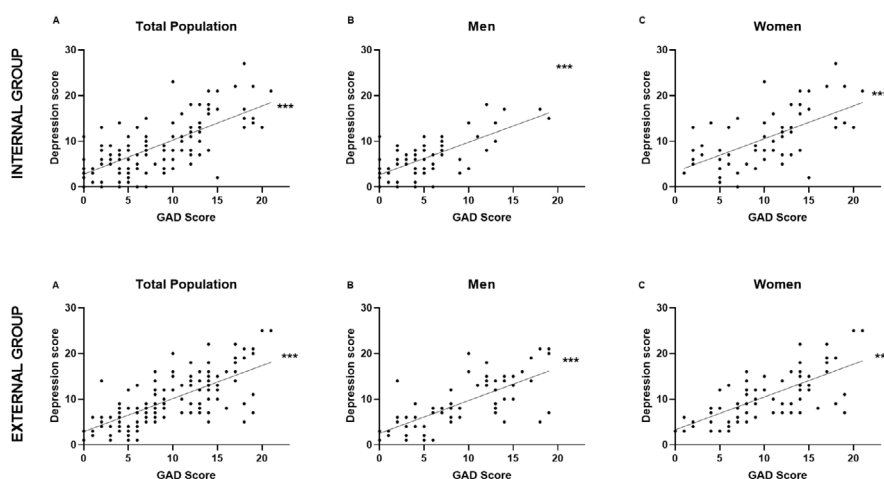


Figure 1. The levels of depression registered in 2020 positively correlate with those of GAD in both genders and populations of university students.

Top panel: Internal Group. Correlation between GAD and Depression scores in (A) the total population ($n=128$, $r=0.669$; $*** p<0.001$), (B) the men population ($n=63$, $r=0.597$; $*** p<0.001$) and (C) the women population ($n=65$, $r=0.621$; $*** p<0.001$).

Bottom panel: External Group. Correlation between GAD and Depression score in (D) the total population ($n=132$, $r=0.707$; $*** p<0.001$), (E) the men population ($n=61$, $r=0.703$; $*** p<0.001$) and (F) the women population ($n=71$, $r=0.689$; $*** p<0.001$).

In all cases a Spearman correlation analysis was performed.

or severe GAD was 39% and 48% and with moderate or severe depression 37% and 46% in the Internal and External groups of students, respectively.

By analysing the relation between the frequency of physical activity and the self-perception of mental health, we observed that those individuals who performed exercise more than twice a week reported lower levels of GAD and depression, regardless they belonged to the Internal (Fig 2 A-B) or the External Group of students (Fig 2 E-F). In turn, we also observed a relationship between the level of social interaction and mood. In this case, we observed that the Internal Group of students who kept high social interaction (HSI, those who sustained SI for six months or more) presented a significantly lower self-perception of GAD and depression than those who kept middle (MSI) and low (LSI) social interaction (Fig 2 C-D). A similar, but not significant, trend to decrease was observed in the GAD levels of the students from the External Group (Fig 2 G).

A posterior gender analysis showed that GAD and depression levels in the men of the Internal Group of students were significantly lower than in the women (Fig 3 A-B). Applying this gender analysis to the level of physical activity and social interaction revealed that women of this group exercised fewer days than men (Fig 3 C; $p < 0.05$) but kept equivalent levels of social interaction (Fig 3 D). Indeed, a contingency analysis revealed significant differences in the distribution of men and women according to the level of physical activity ($p < 0.05$): High physical activity (60% men and 40% women); Low physical activity (39.66% men and 60.39% women). On the contrary, none of these differences was observed in the more heterogeneous External Group of students, where GAD and depression levels were equivalent between genders (Fig 3 E-F).

In January 2021 (from now on 2021) after a valley of infected people and in the valley of registered deaths, we repeated the survey. Here, the cross-sectional analysis confirmed the positive correlation between GAD and depression in both the Internal (Fig 4 A-C) and the External (Fig 4 F-H) Groups of students. Nevertheless, this time the analysis by gender showed no differences between men and women in neither of the groups (Fig 4 D, E, I, J).

Finally, the longitudinal analysis, carried out with those students who answered the surveys twice, revealed that the levels of GAD and depression in 2021

were significantly lower than in 2020 for both the Internal Group (Fig. 5 A, D) and the External Group (Fig 6 A, D). In the case of the Internal Group, the decrease at the populational level was due to the lower records observed in women students (Fig 5 C, F), which also showed an increase in their weekly physical activity compared to the first survey (Fig 5 H). In contrast to women, the men of this group of students kept equivalent levels of GAD, depression and physical activity between the two periods (Fig 5 B, E, G). In the case of the External Group, the decrease in GAD and depression was observed in students of both genders (Fig 6 B, C, E, F). However, this decrease was not associated with changes in the frequency of physical activity (Fig 6 G, H).

Discussion

Depression and GAD represent distinct dimensions of the mental health state; however, it is frequent to see a high comorbidity in the symptoms of these disorders³³. The main findings of the present study, performed in two groups of university students, revealed a significant positive linear regression between the levels of GAD and depression in both men and women. These data were obtained 8 months after the COVID-19 pandemic was declared, after a first peak of contagion and during the first peak of deaths in the Buenos Aires Metropolitan Area, Argentina. The percentage of the students with either moderate or severe GAD was 39% and 48% and with moderate or severe depression 37% and 46% in the Internal and External Groups, respectively. The percentage of subjects who declared social isolation of at least 6 months (low social interaction) was 37% in the Internal Group and 50% in the External one, while those who reported a frequency of physical activity greater than 2 times a week were 55% and 49%, respectively. Our analysis showed a significant decrease in the mean levels of GAD and depression associated with both: a physical activity frequency greater than twice a week as well as to high levels of social interaction. Finally, a longitudinal subsample of students, surveyed two months later when daily contagion cases had decreased by around 30% and the number of daily deaths was in a minimum, showed that their GAD and depression levels decreased significantly with respect to the first survey.

As a starting point, we want to contextualize our

results considering the prevalence of moderate-severe levels of GAD and depression registered in our country from the beginning of the lockdown. In March 2020, a week after the lockdown began, a prevalence of 35% for GAD and 52% for depression was registered in a population of similar age to that of our study²¹. Then, a survey conducted in April 2020, showed that 31.8% of the subjects reported symptoms of anxiety and 27.5% of depression, although here it was recorded in adults between 18 to 92 years old³. Also, there is data from April 2020 focusing on the study of depression and reported prevalence of 41% in young people aged 18 to 27 years, while in June 2020 it was reported 58%³³. Here, the values registered for Oct-Nov 2020 in the university population were 39% and 48% for GAD and 37% and 46% for depression in the Internal and External Groups, respectively. This data suggests that in the young population, the prevalence of GAD has shown a slight but sustained increase and that depression begins to show a slight decrease from the start of the lockdown.

In the present work, we also performed a longitudinal study in a subsample of participants. We observed that both depression and GAD mean scores significantly decreased in the second survey performed two months later, probably reflecting the decrease in the fatality rates and the holiday period that preceded that survey. On the other hand, a study conducted in the United States in participants surveyed to study these symptoms, earlier in the COVID-19 outbreak and a month later, showed an increase in GAD and depression levels. Personal distancing behaviour was associated with these increases¹⁴. Also, the prevalence of depression and GAD increases slightly in Spain, reaching 37%, 46% respectively, when the authors relieved these data first at the peak with approximately 8000 infections a day and then a month later with half of infections³⁵. Further studies are necessary to understand how the progress of the pandemic affects mental health.

There are multiple factors that could influence psychological distress^{3,36}. In this work, we focused on two of these, physical activity, and social interaction. Regular physical activity is a key health behaviour related to a lower risk of mental disturbance³⁷. Rebar et al.³⁸, reported significant inverse associations between physical activity participation with depression and anxiety levels in their meta-analysis performed in

2015. A similar scenario is being observed during the COVID-19 pandemic. In that sense, Wolf et al.²⁵ published a systematic review showing that those persons who reported a higher total time spent in moderate to vigorous physical activity also had 12% to 32% lower chances of presenting depressive symptoms and 15–34% of presenting anxiety. In addition, other studies carried out in adult people showed a significant association of negative changes in the activity scores with worse depression, anxiety and stress during 2020^{39,36}.

Recent evidence shows that the amount of walking, the level of moderate or vigorous physical activity as well as the total exercise performed, have been reduced during the COVID-19 pandemic confinements in 3.500 university students from eight different countries²⁴. In a study carried out in Italy, it was observed that in all age groups, there is a significant reduction in the total physical activity observed during COVID-19, even though this change was more noticeable in men. Also, subjects classified as highly active and moderately active showed a significant correlation between the change in total activity and the Psychological General Well-Being Index, which included life domains like anxiety and depression⁴⁰. Here, we observed in a group of Argentinean university students that performing physical activity more than twice a week was associated with a significant decrease in the average GAD and depression scores. Moreover, in the women of the Internal Group of Students, the longitudinal study showed that the decrease in the levels of these emotional states correlated with an increase in their physical activity levels. In line with our results, recent research performed a survey in Austria and showed that the groups with GAD and depression levels lower than 10 were enriched in subjects who practice physical activity more than twice a week, something that was not observed in the group with moderate-severe scores⁸. Even more, another study conducted in Spain revealed that people who performed daily exercise for two weeks before the surveys presented reduced levels of depression and stress, although this work was not focused on university students³⁵. Our results show that frequent physical activity is associated with lower GAD and depression scores in university students impacted by pandemic.

Polero et al.⁴¹ reviewed the recommendations for performing physical activity during the pandemic. According to these studies, and in agreement

with the WHO recommendations, they suggested performing at least 150 min of moderate-intensity or 75 min of vigorous physical activity per week. In particular, the neurobiological mechanisms by which physical activity affects the levels of anxiety, reactivity to stress, depression and mood, include the regulation of the hypothalamic-pituitary-adrenal axis, effects on the endogenous opioid system and the increase of the brain-derived neurotrophic factor level⁴²⁻⁴⁴. Thus, owing to the interruption of physical activity routines due to anti-contagion policies, it is worth noting the importance of promoting a change of behaviour in exercise habits, including online physical activity with friends or a virtual community, which might work in favour of social support to continue these activities.

The other factor considered in this work, which could influence psychological distress, was the social interaction. Our results suggested that the subjects who kept high non-virtual social interaction presented lower self-perception of GAD and depression than those of the groups with medium to low interaction levels. These changes were mild in the External Group of Students but marked in the Internal one (about 3 to 5 points in the scores). A survey performed by Marroquin et al.¹⁴ in 118 US participants showed increases in GAD and depression associated with personal distancing behaviour. In that work, the absolute changes in the symptoms were statistically significant but relatively modest (about 1 point in the scores). Another work showed that the risk of mental illness was higher among quarantined China people than among the not quarantined, even in unaffected areas¹⁶. Elevated psychological distress was also found among quarantined Chinese respondents during March 2020, which represented 12,5% of the sample¹¹. Some of the difficulties that make the quarantine an anxious and depressive experience include the feeling of being confined, the separation from family, the disruption of regular social activities, the problem of not getting paid because of missed work, and uncertainty regarding contracting the disease^{45,16}. So, after reviewing 24 studies, Brooks et al.¹² warn about the potential psychological impact of the quarantine or the social isolation, alerting that their duration period should be limited to what is necessary in order to control the climax of the pandemic.

Finally, some evidence reveals a greater psycho-

logical impact of COVID-19 on women, showing higher levels of stress, anxiety, and depression, compared to men. The research of Fernandez et al.³ performed in Argentina supports this assertion. In our study, we observed differences between genders only in the Internal Group of students, where men declared fewer symptoms of GAD and depression than women in the survey from 2020. This result was associated with a higher proportion of men students performing high physical activity compared to women of the same group. On the other hand, a non-significant but notorious trend to maintain high social interaction was observed also in the men students of the Internal Group. In addition, it is possible that other factors unexplored during this study could also influence the difference in GAD and depression between genders. It is worth noting that the gender differences in GAD, depression, physical activity, and social interaction were not observed in the External Group of students. A plausible explanation for this discrepancy may have originated from the differences in homogeneity between these groups. While the Internal Group was composed of confirmed students at a technical university located in Buenos Aires city, the External Group was composed of students at multiple universities, which could be public or private, that offer a wide range of careers (i.e. from philosophy to medicine), and that are in distinct sections of the Buenos Aires Metropolitan Area. Whereas studies conducted in Greek, Cypriot and Ireland communities found some mood sexual dimorphism^{5,7,9}, other surveys performed on college students in China or in 1000 Australian people did not show such effects^{13,36}. However, in those works a low average score for anxiety and depression was found.

In summary, our study shows that University students of the Buenos Aires Metropolitan Area in Argentina had values of GAD and depression that correlated in a linear and positive way in two different time periods of the COVID-19 pandemic. In addition, longitudinal analysis revealed that GAD and depression levels decreased in January 2021 when daily contagion cases had decreased and during a minimum of reported deaths. The analysis also revealed that a frequency of physical activity higher than twice a week was associated with a decrease in the average score of these emotional states. It also suggested that a higher social interaction was associated with decreased levels of GAD and depression.

Based on our results, we argue that governments should consider the importance of physical exercise and the social interactions in mental health of university student, and therefore implement policies to promote these activities under health safety standards, such as social distancing in open spaces, to restrict the viral propagation.

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Access to materials: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Supplementary Materials: Table S1, Table S2, Table S3, Table S4, Table S5 and Table S6

Institutional Review Board Statement: This study was approved by the ethics council of the Life Sciences Department of the Instituto Tecnológico de Buenos Aires. All the procedures conducted in this study followed the ethical standards of the institutional and national research committees as well as those of the Helsinki Declaration of 1975, as revised in 2008.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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References

1. Bäuerle A, Teufel M, Musche V, Weismüller B, Kohler H, Hektamp M, et al. Increased generalized anxiety, depression and distress during the COVID-19 pandemic: A cross-sectional study in Germany. *Journal of Public Health*. 2020 Jul 13;42(4):672–8. <https://doi.org/10.1093/pubmed/fdaa106>
2. Choi EPH, Hui BPH, Wan EYF. Depression and Anxiety in Hong Kong during COVID-19. *International Journal of Environmental Research and Public Health*. 2020 May 25;17(10):3740. <https://doi.org/https://doi.org/10.3390/ijerph17103740>
3. Lozano-Díaz A, Fernández-Prados JS, Figueredo Canosa V, Martínez Martínez AM. Impactos del confinamiento por el COVID-19 entre universitarios: Satisfacción Vital, Resiliencia y Capital Social Online. *International Journal of Sociology of Education*. 2020 Jun 20;79–104. <https://doi.org/10.17583/rise.2020.5925>
4. Huang Y, Zhao N. Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based cross-sectional survey. *Psychiatry Research*. 2020 Jun; 288:112954. <https://doi.org/10.1016/j.psychres.2020.112954>
5. Hyland P, Shevlin M, McBride O, Murphy J, Karatzias T, Bental RP, et al. Anxiety and depression in the Republic of Ireland during the COVID-19 pandemic. *Acta Psychiatrica Scandinavica*. 2020 Aug 9;142(3):249–56.
6. Liu CH, Zhang E, Wong GTF, Hyun S, Hahm H "Chris." Factors associated with depression, anxiety, and PTSD symptomatology during the COVID-19 pandemic: Clinical implications for U.S. young adult mental health. *Psychiatry Research*. 2020 Aug; 290:113172. <https://doi.org/https://doi.org/10.1097/mlr.0b013e318160d093>
7. Parlapani E, Holeva V, Voitsidis P, Blekas A, Gliatas I, Porfyri GN, et al. Psychological and Behavioral Responses to the COVID-19 Pandemic in Greece. *Frontiers in Psychiatry*. 2020 Aug 19;11. <https://doi.org/10.3389/fpsy.2020.00821> <https://doi.org/10.1155/2017/7260130>
8. Pieh C, Budimir S, Probst T. The effect of age, gender, income, work, and physical activity on mental health during coronavirus disease (COVID-19) lockdown in Austria. *Journal of Psychosomatic Research*. 2020 Sep; 136:110186. <https://doi.org/10.1016/j.jpsychores.2020.110186>
9. Solomou I, Constantinidou F. Prevalence and Predictors of Anxiety and Depression Symptoms during the COVID-19 Pandemic and Compliance with Precautionary Measures: Age and Sex Matter. *International Journal of Environmental Research and Public Health*. 2020 Jul 8;17(14):4924. <https://doi.org/doi:10.3390/ijerph17144924>
10. Wang C, Pan R, Wan X, Tan Y, Xu L, Ho CS, et al. Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. *International Journal of Environmental Research and Public Health*. 2020

- Mar 6;17(5):1729. <https://doi.org/https://doi.org/10.3390/ijerph17051729>
11. Ben-Ezra M, Sun S, Hou WK, Goodwin R. The association of being in quarantine and related COVID-19 recommended and non-recommended behaviors with psychological distress in Chinese population. *Journal of Affective Disorders*. 2020 Oct; 275:66–8. <https://doi.org/10.1016/j.jad.2020.06.026>
 12. Brooks SK, Webster RK, Smith LE, Woodland L, Wessely S, Greenberg N, et al. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *The Lancet*. 2020 Mar;395(10227):912–20. [https://doi.org/10.1016/S0140-6736\(20\)30460-8](https://doi.org/10.1016/S0140-6736(20)30460-8)
 13. Cao W, Fang Z, Hou G, Han M, Xu X, Dong J, et al. The psychological impact of the COVID-19 epidemic on college students in China. *Psychiatry Research*. 2020 May; 287:112934. <https://doi.org/10.1016/j.psychres.2020.112934>
 14. Marroquín B, Vine V, Morgan R. Mental health during the COVID-19 pandemic: Effects of stay-at-home policies, social distancing behavior, and social resources. *Psychiatry Research*. 2020 Nov; 293:113419. <https://doi.org/10.1016/j.psychres.2020.113419>
 15. Rubin GJ, Wessely S. The psychological effects of quarantining a city. *BMJ*. 2020 Jan 28;m313. <https://doi.org/10.1136/bmj.m313>
 16. Tang F, Liang J, Zhang H, Kelifa MM, He Q, Wang P. COVID-19 related depression and anxiety among quarantined respondents. *Psychology & Health*. 2020 Jun 22;36(2):164–78. <https://doi.org/10.1080/08870446.2020.1782410>
 17. Tull MT, Edmonds KA, Scamaldo KM, Richmond JR, Rose JP, Gratz KL. Psychological Outcomes Associated with Stay-at-Home Orders and the Perceived Impact of COVID-19 on Daily Life. *Psychiatry Research*. 2020 Jul; 289:113098.
 18. BOLETIN OFICIAL REPUBLICA ARGENTINA - AISLAMIENTO SOCIAL, PREVENTIVO Y OBLIGATORIO Y DISTANCIAMIENTO SOCIAL, PREVENTIVO Y OBLIGATORIO [Internet]. Decreto 875/2020. [cited 2022 Dec 2]. Available from: <https://www.boletinoficial.gob.ar/detalleAviso/primera/237062/20201107>
 19. BOLETIN OFICIAL REPUBLICA ARGENTINA - AISLAMIENTO SOCIAL PREVENTIVO Y OBLIGATORIO [Internet]. Decreto 297/2020. [cited 2022 Dec 2]. Available from: <http://www.boletinoficial.gob.ar/detalleAviso/primera/227042/20200320>
 20. Ministerio de Salud. Informes diarios [Internet]. Argentina. gov.ar. 2020 [cited 2022 Dec 28]. Available from: <https://www.argentina.gob.ar/coronavirus/informes-diarios/repotes/noviembre2020%0A>
 21. Torrente F, Yoris A, Low DM, Lopez P, Bekinschtein P, Manes F, et al. Sooner than you think: A very early affective reaction to the COVID-19 pandemic and quarantine in Argentina. *Journal of Affective Disorders*. 2021 Mar; 282:495–503. <https://doi.org/10.1016/j.jad.2020.12.124>
 22. Dhar BK, Ayithey FK, Sarkar SM. Impact of COVID-19 on Psychology among the University Students. *Global Challenges*. 2020 Sep 28;4(11):2000038. <https://doi.org/https://doi.org/10.1002/gch2.202000038>
 23. Caspersen CJ, Powell KE, Christenson CM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep*. 1985;100(2):126–31.
 24. López-Valenciano A, Suárez-Iglesias D, Sanchez-Lastra MA, Ayán C. Impact of COVID-19 Pandemic on University Students' Physical Activity Levels: An Early Systematic Review. *Frontiers in Psychology*. 2021 Jan 15;11.
 25. Wolf S, Seiffer B, Zeibig JM, Welkerling J, Brokmeier L, Atrott B, et al. Is Physical Activity Associated with Less Depression and Anxiety During the COVID-19 Pandemic? A Rapid Systematic Review. *Sports Medicine*. 2021 Apr 22;51(8):1771–83. <https://doi.org/10.1007/s40279-021-01468-z>
 26. Spitzer RL, Kroenke K, Williams JBW, Löwe B. A Brief Measure for Assessing Generalized Anxiety Disorder. *Archives of Internal Medicine*. 2006 May 22;166(10):1092. <https://doi.org/https://doi.org/10.1001/archinte.166.10.1092>
 27. American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 4th ed. Washington, DC; 1994.
 28. Löwe B, Decker O, Müller S, Brähler E, Schellberg D, Herzog W, et al. Validation and Standardization of the Generalized Anxiety Disorder Screener (GAD-7) in the General Population. *Medical Care*. 2008 Mar;46(3):266–74.
 29. Plummer F, Manea L, Trepel D, McMillan D. Screening for anxiety disorders with the GAD-7 and GAD-2: a systematic review and diagnostic metaanalysis. *General Hospital Psychiatry*. 2016 Mar; 39:24–31. <https://doi.org/10.1016/j.genhosppsych.2015.11.005>
 30. Kroenke K, Spitzer RL, Williams JBW. The PHQ-9. *Journal of General Internal Medicine*. 2001 Sep;16(9):606–13. Beard C, Hsu KJ, Rifkin LS, Busch AB, Björgvinsson T. Validation of the PHQ-9 in a psychiatric sample. *Journal of Affective Disorders*. 2016 Mar; 193:267–73. <https://doi.org/https://doi.org/10.1046/j.1525-1497.2001.016009606.x>
 31. Beard C, Hsu KJ, Rifkin LS, Busch AB, Björgvinsson T. Validation of the PHQ-9 in a psychiatric sample. *Journal of Affective Disorders*. 2016 Mar; 193:267–73. <https://doi.org/10.1016/j.jad.2015.12.075>
 32. Titov N, Dear BF, McMillan D, Anderson T, Zou J, Sunderland M. Psychometric Comparison of the PHQ-9 and BDI-II for Measuring Response during Treatment of Depression. *Cognitive Behaviour Therapy*. 2011 Jun;40(2):126–36. <https://doi.org/10.1080/16506073.2010.550059>
 - Clark DA, Steer RA, Beck AT. Common and specific dimensions of self-reported anxiety and depression: Implications for the cognitive and tripartite models. *Journal of Abnormal Psychology*. 1994 Nov;103(4):645–54.
 33. Badellino H, Gobbo ME, Torres E, Aschieri ME, Biotti M, Alvarez V, et al. 'It's the economy, stupid': Lessons of a longitudinal study of depression in Argentina. *International Journal of Social Psychiatry*. 2021 Mar 11;68(2):384–91. <https://doi.org/10.1177/0020764021999687>
 34. Planchuelo-Gómez Á, Odriozola-González P, Iruñia MJ, de Luis-García R. Longitudinal evaluation of the psychological impact of the COVID-19 crisis in Spain. *Journal of Affective Disorders*. 2020 Dec; 277:842–9. <https://doi.org/10.1016/j.jad.2020.09.018>
 35. Stanton R, To QG, Khalesi S, Williams SL, Alley SJ, Thwaite TL, et al. Depression, Anxiety and Stress during COVID-19:

- Associations with Changes in Physical Activity, Sleep, Tobacco and Alcohol Use in Australian Adults. *International Journal of Environmental Research and Public Health*. 2020 Jun 7;17(11):4065. <https://doi.org/https://doi.org/10.3390/ijerph17114065>
36. Raglin JS. Exercise and Mental Health. *Sports Medicine*. 1990 Jun;9(6):323–9. <https://doi.org/https://doi.org/10.2165/00007256-199009060-0000>
 37. Rebar AL, Stanton R, Geard D, Short C, Duncan MJ, Vandellanno C. A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychology Review*. 2015 Jul 3;9(3):366–78. <https://doi.org/10.1080/17437199.2015.1022901>
 38. Meyer J, McDowell C, Lansing J, Brower C, Smith L, Tully M, et al. Changes in Physical Activity and Sedentary Behavior in Response to COVID-19 and Their Associations with Mental Health in 3052 US Adults. *International Journal of Environmental Research and Public Health*. 2020 Sep 5;17(18):6469. <https://doi.org/https://doi.org/10.3390/ijerph17186469>
 39. Maugeri G, Castrogiovanni P, Battaglia G, Pippi R, D'Agata V, Palma A, et al. The impact of physical activity on psychological health during Covid-19 pandemic in Italy. *Heliyon*. 2020 Jun;6(6): e04315. <https://doi.org/10.1016/j.heliyon.2020.e04315>
 40. Polero P, Rebollo-Seco C, Adsuar JC, Pérez-Gómez J, Rojo-Ramos J, Manzano-Redondo F, et al. Physical Activity Recommendations during COVID-19: Narrative Review. *International Journal of Environmental Research and Public Health*. 2020 Dec 24;18(1):65. <https://doi.org/10.3390/ijerph18010065>
 41. Bodnar RJ, Klein GE. Endogenous opiates and behavior: 2004. *Peptides*. 2005 Dec;26(12):2629–711. <https://doi.org/10.1016/j.peptides.2005.06.010>
 42. Phillips C. Brain-Derived Neurotrophic Factor, Depression, and Physical Activity: Making the Neuroplastic Connection. *Neural Plasticity*. 2017; 2017:1–17.
 43. Rimmele U, Zellweger BC, Marti B, Seiler R, Mohiyeddini C, Ehlert U, et al. Trained men show lower cortisol, heart rate and psychological responses to psychosocial stress compared with untrained men. *Psychoneuroendocrinology*. 2007 Jul;32(6):627–35. <https://doi.org/10.1016/j.psyneuen.2007.04.005>
 44. Blendon RJ, Benson JM, DesRoches CM, Raleigh E, Taylor-Clark K. The Public's Response to Severe Acute Respiratory Syndrome in Toronto and the United States. *Clinical Infectious Diseases*. 2004 Apr;38(7):925–31. <https://doi.org/doi:10.1086/382355>

Figure and Figure Legends

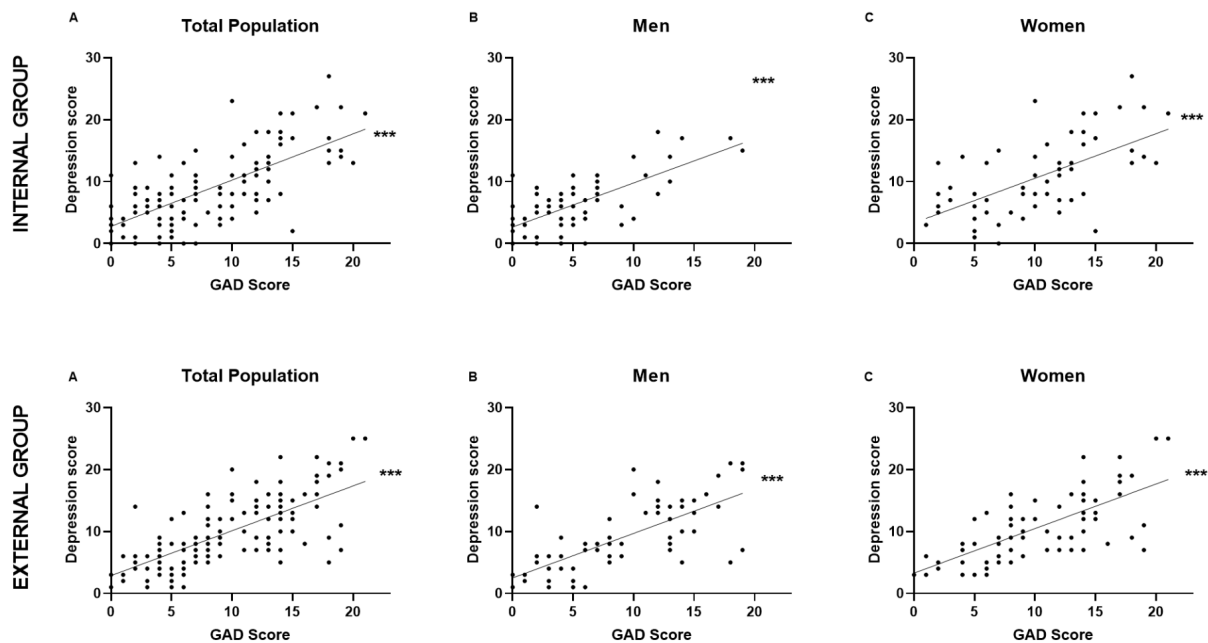


Figure 1. The levels of depression registered in 2020 positively correlate with those of GAD in both genders and populations of university students. **Top panel:** Internal Group. Correlation between GAD and Depression scores in (A) the total population ($n=128$, $r=0.669$; $*** p<0.001$), (B) the men population ($n=63$, $r=0.597$; $*** p<0.001$) and (C) the women population ($n=65$, $r=0.621$; $*** p<0.001$). **Bottom panel:** External Group. Correlation between GAD and Depression score in (D) the total population ($n=132$, $r=0.707$; $*** p<0.001$), (E) the men population ($n=61$, $r=0.703$; $*** p<0.001$) and (F) the women population ($n=71$, $r=0.689$; $*** p<0.001$). In all cases a Spearman correlation analysis was performed.

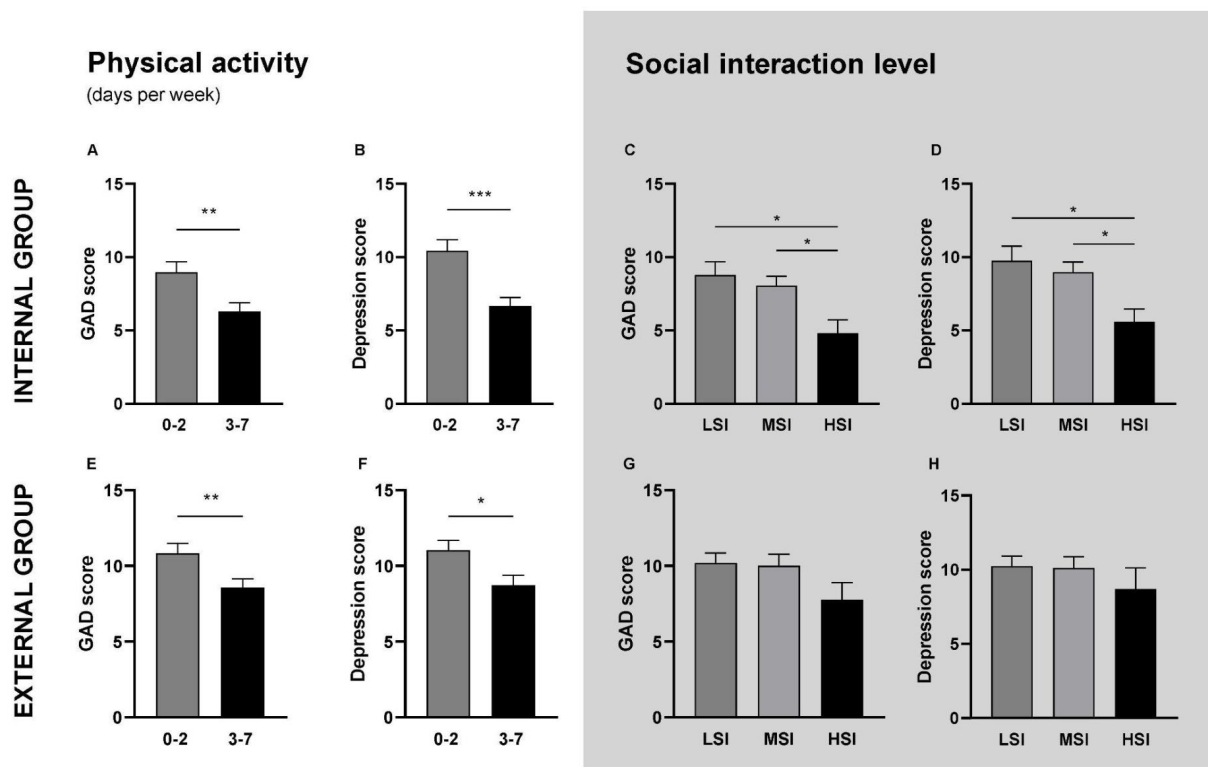


Figure 2. Higher physical activity frequency and longer periods of social interaction are associated with lower levels of GAD and depression. Figures show the level of GAD and Depression scores, depicted as mean +/- SEM, based on the days of physical activity per week (left panel) and the level of social interaction (right panel). **(A)** GAD and **(B)** Depression scores in the Internal Group of students who performed physical activity up to 2 days per week (gray bars, n=70-65, respectively) or between 3 to 7 (black bars, n=58); Mann-Whitney t-test, **p < 0.01, ***p < 0.001. **(C)** GAD and **(D)** Depression scores in the Internal Group of students who kept Low (LSI, dark gray bars, n=47-47), Medium (MSI, light gray bars, n=59-59) or a High (HSI, black bars, n=22-22) Social Interaction; Kruskal-Wallis test analysis after One-way ANOVA, *p < 0.05. **(E)** GAD and **(F)** Depression scores in the External Group of students who performed physical activity up to 2 days per week (gray bars, n=74-74, respectively) or between 3 to 7 days (black bars, n=58); Student's t-test, *p < 0.05, **p < 0.01. **(G)** GAD and **(H)** Depression scores in the External Group of students who kept Low (LSI, dark gray bars, n=66), Medium (MSI, light gray bars, n=49) or High (HSI, black bars, n=16) Social Interaction (p > 0.05).

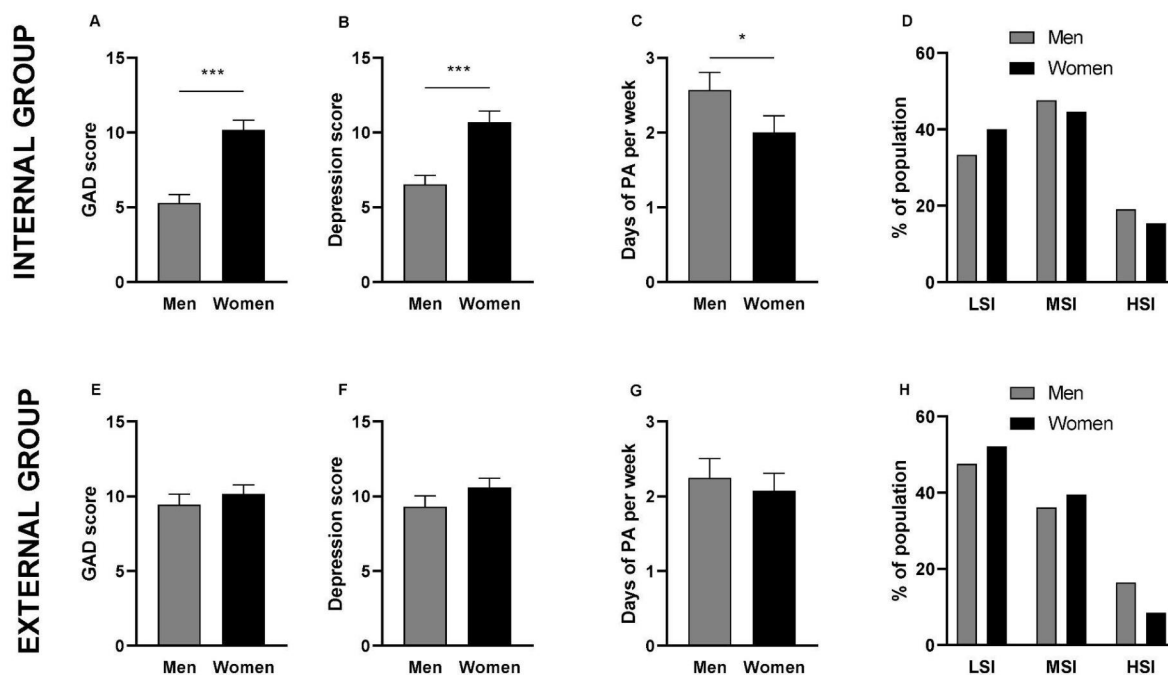


Figure 3. Men students of the Internal Group had lower levels of GAD and depression, while performing more days of physical activity, than women in the 2020. Top panel: Internal Group (men n=63, women n=65). Figures show (A) GAD levels (*p*<0.001, Student's t-test), (B) Depression levels (***p*<0.001, one-tailed Mann-Whitney), and (C) day of physical activity (* *p*<0.05, one-tailed Mann-Whitney) expressed as mean +/- SEM. (D) the distribution of Social Interaction (as % of population. HLSI, MSI and HSI: Low, Medium and High Social Interaction, respectively. *p*>0.05, Chi-Square) between men (gray bars) and women (black bars). Bottom panel: External Group (men n=61, women n=71). Figures show (E) GAD levels (*p*>0.05 one-tailed Mann-Whitney), (F) Depression levels (*p*>0.05, one-tailed Mann-Whitney), and (G) day of physical activity (*p*>0.05, one-tailed Mann-Whitney) expressed as mean +/- SEM. (H) the distribution of Social Interaction (*p*>, 0.05 Chi-Square) between men (gray bars) and women (black bars).**

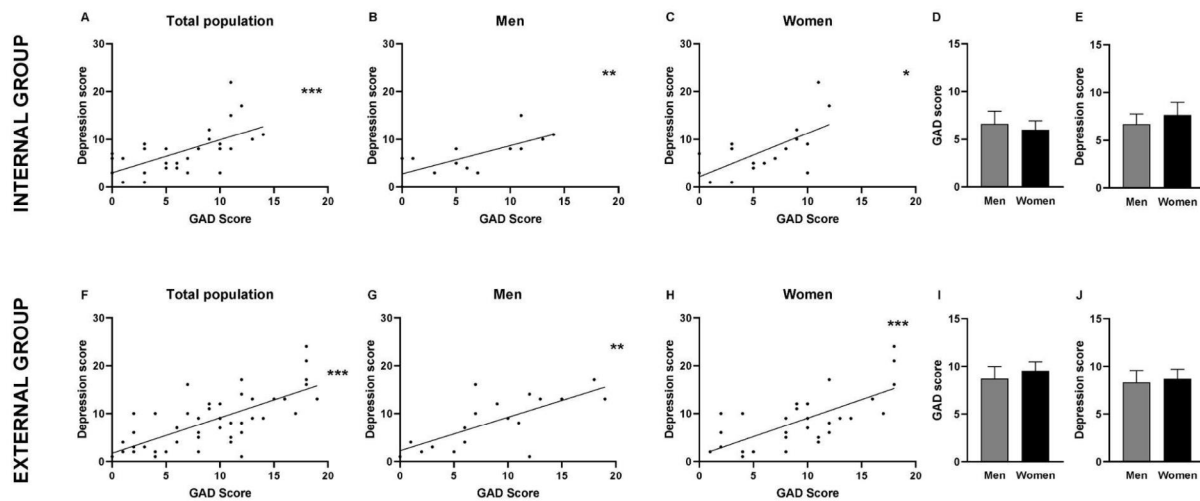


Figure 4. The levels of depression registered in 2021 also correlated positively with those of GAD in both genders and groups; besides the differences between genders in the Internal Group vanished. Top panel: Internal Group. Correlation between GAD and Depression scores in (A) total population ($n=30$, $r=0,626$, $*p < 0.001$, Spearman correlation), (B) men population ($n=13$, $r=0,716$, $**p < 0.01$, Spearman correlation) and (C) women population ($n=17$, $r=0,612$, $*p < 0.05$, Spearman correlation). GAD (D) and Depression (E) scores of men (gray bars, $n=13$) and women (black bars, $n=17$) expressed as mean + SEM (one-tailed Mann-Whitney, $p > 0.05$). Bottom panel: External Group. Correlation between GAD and Depression scores in (F) total population ($n=47$, $r=0,663$, $***p < 0.001$, Spearman correlation), (G) men population ($n=18$, $r=0,698$, $**p < 0.01$, Spearman correlation) and (H) women population ($n=29$, $r=0,628$, $***p < 0.001$, Spearman correlation). (I) GAD and (J) Depression scores of men (gray bars, $n=18$) and women (black bars, $n=29$) expressed as mean + SEM (one-tailed Mann-Whitney, $p > 0,05$).**

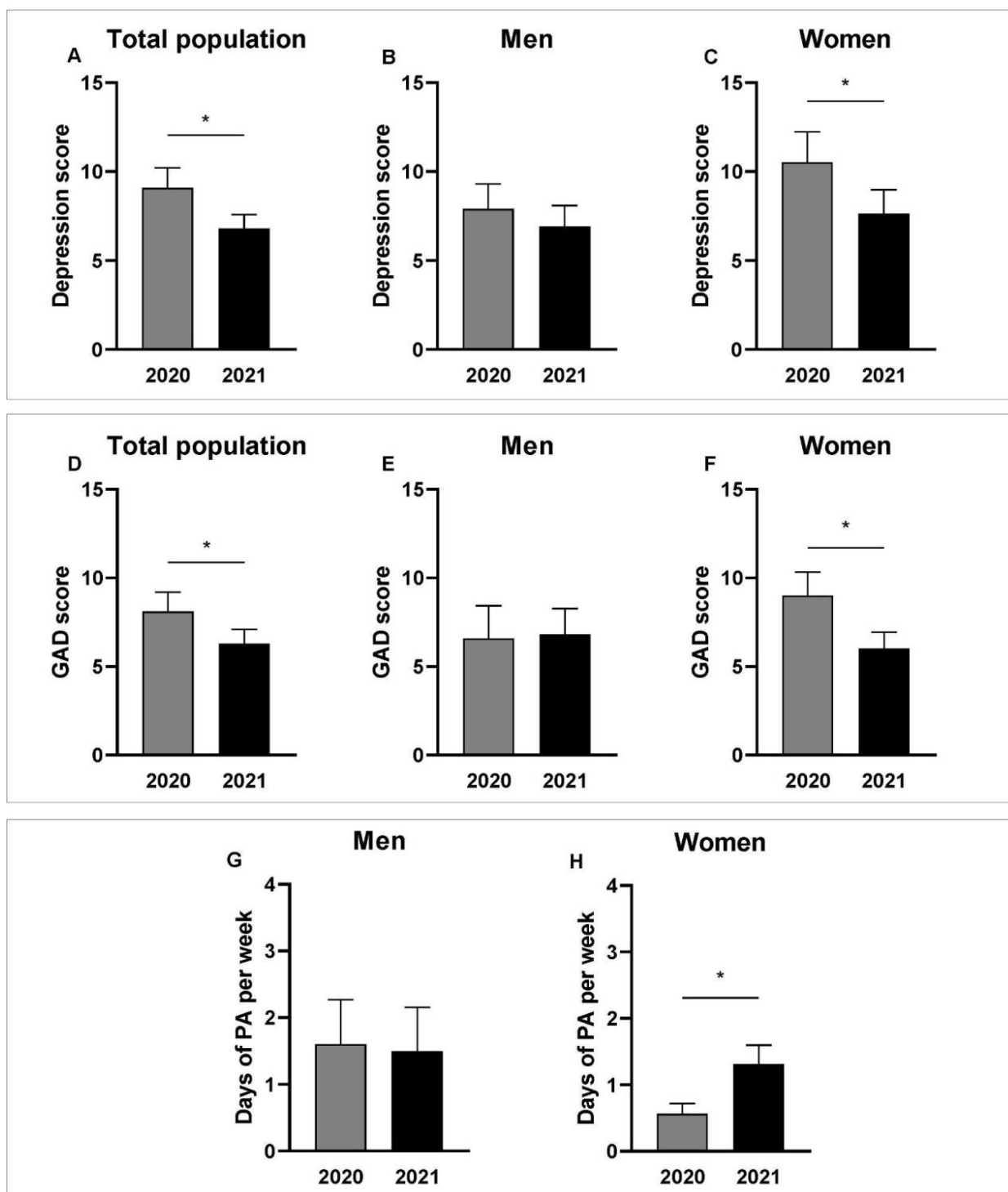


Figure 5. Longitudinal analysis of GAD score, depression level and days of physical activity in the Internal Group between 2020 and 2021. Top Panel: Depression scores for (A) the total population ($n=26$, an outlier was removed. Wilcoxon Paired t -test, $* p < 0.05$), (B) the men students ($n=10$. Wilcoxon paired t -test, $p > 0.05$) and (C) the women students ($n=17$, Wilcoxon paired t -test, $* p < 0.05$). **Medium Panel:** GAD score for (D) the total of students ($n=27$ Wilcoxon paired t -test, $* p < 0.05$), (E) the men students ($n=10$, Wilcoxon Paired t -test $p > 0.05$) and (F) the women students ($n=17$, Wilcoxon Paired t -test, $* p < 0.05$). **Bottom panel:** days of physical activity per week in (G) the men ($n= 10$, Wilcoxon paired t -test $p > 0.05$) and (H) women ($n=17$, Wilcoxon paired t -test $* p < 0.05$) students. All data is expressed as mean + SEM.

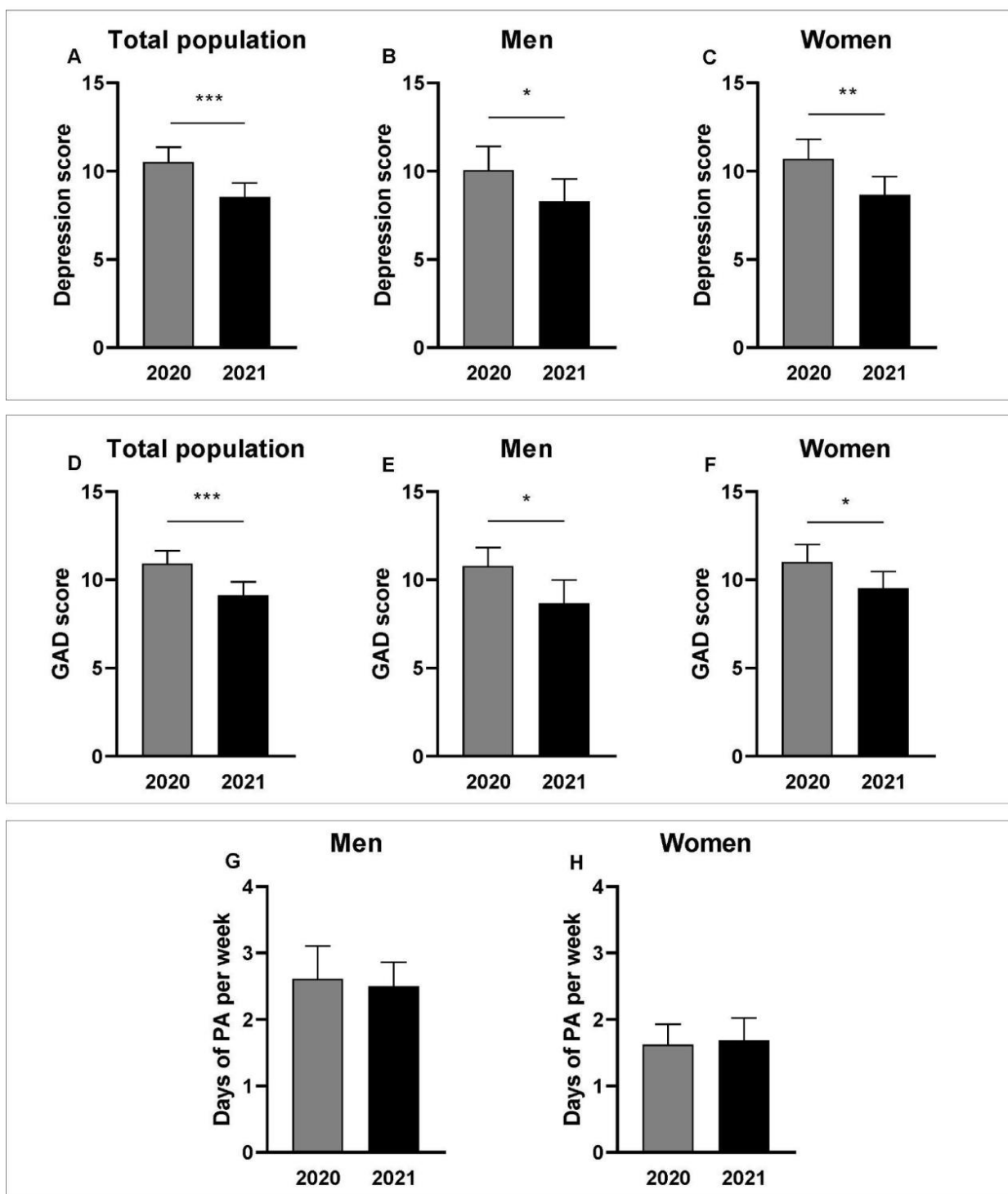


Figure 6. Longitudinal analysis of GAD scores, depression levels and days of physical activity in the External Group between 2020 and 2021. Top Panel: Depression scores for (A) the total population (n=47, Wilcoxon Paired t-test, *** p<0.001) (B) the men students (n=18, Wilcoxon Paired t-test, * p<0.05) and (C) the women students (n=29, Wilcoxon Paired t-test, ** p<0.01). **Medium Panel:** GAD score for (D) the total of students (n=47, Wilcoxon Paired t-test, *** p<0.001), (E) the men students (n=18, Wilcoxon Paired t-test, * p<0.05) and (F) the women students (n=29, Wilcoxon Paired t-test, * p<0.05). **Bottom panel:** days of physical activity per week in (G) the men (n=18) and (H) women students (n=29) (Wilcoxon Paired t-test, p>0,05). Data are expressed as mean + SEM.