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The Link Between COVID-19 and Executive Functions in the Geriatric Population: A Descriptive Cross-Sectional Study

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ABSTRACT

Objective: Geriatric population is known to be at a greater risk for the Coronavirus-19 (COVID-19). Previous literature provided evidence for the association between viral infections and cognitive decline. The aim of this study was to evaluate executive functions in older adults who were infected by COVID-19.

Material and Methods: A total of 47 participants with healthy cognition over the age of 65 (M:75.4±5.91, minimum-maximum:65-85) were enrolled in the study. The sample was selected from older adults residing in a nursing home in Istanbul. Based on their history of COVID-19 infection, the sample was divided into two groups as COVID-P (22 participants who got Covid-19 in the last six months) and COVID-N (25 participants who did not get Covid-19) which did not significantly differ in terms of age and education. A mini mental state examination was applied to verify the mental status of participants. Trail Making Test (TMT) and Clock Drawing test (CDT) were used to assess executive functions.

Results: The analyses showed that COVID-P group displayed significantly lower performance in the completion time of TMT as compared to COVID-N group ($p < .05$ for both TMT-A and TMT-B). However, groups did not significantly differ in their CDT performance ($p > .05$).

Conclusion: Based on the findings, it is possible to conclude that COVID-19 can negatively affect the executive functions in the old age population.

Keywords: COVID-19; aging; cognition; executive functions

Geriatrik Popülasyonda COVID-19 ve Yürütücü İşlevler Arasındaki İlişki: Tanımlayıcı Kesitsel Bir Çalışma

ÖZET

Amaç: Geriyatrik popülasyonun Koronaviruse (COVID-19) yakalanma riskinin daha yüksek olduğu bilinmektedir. Geçmiş literatüre bakıldığında, viral enfeksiyonlar ile bilişsel bozulma arasında bir ilişki görülmektedir. Bu çalışmanın amacı COVID-19 geçirmiş yaşlılarda yürütücü işlevlerin değerlendirilmesidir.

Gereç ve Yöntem: Çalışmaya 65 yaş ve üzeri (M:75.4±5.91, minimum-maksimum:65-85) toplam 47 bilişsel olarak sağlıklı yaşlı dahil edilmiştir. Örneklem, İstanbul'da bir huzurevinde ikamet eden yaşlı bireylerden oluşturulmuştur. COVID-19 öyküsüne göre, örneklem COVID-P (son 6 ayda Covid-19 geçirmiş olan 22 katılımcı) ve COVID-N (Covid-19 geçirmemiş 25 katılımcı) olmak üzere yaş ve eğitim düzeyi açısından anlamlı fark bulunmayan iki gruba ayrılmıştır. Katılımcıların mental durumlarının değerlendirilmesi amacıyla Mini Mental Durum Testi uygulanmıştır. Yürütücü işlevler, İz Sürme Testi (İST) ve Saat Çizimi Testi (SÇT) uygulanarak ölçülmüştür.

Bulgular: Yapılan analizler sonucunda COVID-P grubunun İST tamamlama süresi performansı her iki form için de COVID-N grubuna göre daha düşük bulunmuştur (hem İST-A hem İST-B için $p < .05$). Öte yandan gruplar SÇT performansı açısından istatistiksel olarak farklı bulunmamıştır ($p > .05$).

Sonuç: Elde edilen bulgulara göre, COVID-19'un yaşlı popülasyonda yürütücü işlev performansını negatif yönde etkilediği sonucuna varmak mümkün olabilir.

Anahtar Kelimeler: COVID-19; yaşlanma; biliş; yürütücü işlevler

As leading to a severe acute respiratory syndrome, the COVID-19 pandemic has affected more than 400 million people throughout the world and resulted in approximately 6 million deaths (https://covid19.who.int/). We witnessed that older population was one of the highest risk groups to experience adverse effects of the virus and potential deaths.

Even though COVID-19 infection mainly targets the human respiratory system, it is now clear that COVID-19 can lead to long-lasting damages in multiple systems including the nervous system. Accordingly, a reasonable number of COVID-19 cases has been found to develop neurological symptoms. In parallel with this, COVID-19 infection has been also associated with impairment in different cognitive domains ranging from attention to executive functions (1). In addition to the direct neurological impact, long-term self-isolation periods as well as the traumatic stress of the disease itself can have a negative impact on cognition of older population (2).

In a cohort study conducted with COVID-19 survivors in Wuhan, it was shown that severe COVID-19 as compared to nonsevere COVID-19 was significantly related to progressive cognitive decline in older adults (3). In another study, worsening of cognitive decline was reported as a significant impact of COVID-19 on people with dementia (4). Also, older adults who cleared the virus were found to experience executive dysfunction as well as increased anxiety and depression (2). Recently, a study conducted with Turkish population evaluated post-covid cognitive deficits and a positive correlation was reported between patients' initial Serum C-reactive protein (CRP) levels and severity of cognitive impairment (5). In addition, cognitive performance of the patients who were hospitalized due to COVID-19 were reported to be worse than the patients who were not hospitalized. In fact, the effect of viral infections other than COVID-19 on neurocognitive functioning had been previously reported in several studies (6-8).

Given that old age people are more vulnerable to this infection, their risk of post-COVID-19 cognitive decline should be a topic of concern. Therefore, the aim of this study was to evaluate the impact of COVID-19 on executive functions among older adults.

Material and Methods

Study Design

The study was designed as a descriptive cross-sectional research model. The study was conducted in accordance with Helsinki Declaration Principles. An informed consent was taken from all participants before collecting the data. The study was approved by Uskudar University Non-Interventional Research Ethics Committee, report number of 61351342/07/2021-30 (29 July 2021).

Sample

Twenty-two participants with the history of COVID-19 (COVID-P) and 25 participants without the history of COVID-19 (COVID-N) were included in the study. Since the target population of the study was old age people, participants were recruited from a nursing home in Istanbul. Participants' mental state was assessed by MMSE and a total score of less than 26 was set as an exclusion criterion. Illiteracy and any history of neurological and psychiatric disorder were also set as exclusion criteria. Being aged 65 or above, having a total score of more than 26 in MMSE and the absence of any neurological and psychiatric disorder were set as inclusion criteria.

Measurement Tools

Clock Drawing Test (CDT)

Clock Drawing Test (CDT) is one of the most widely used and easily applied tests to assess executive functions. Despite its several versions and scoring methods, the general procedure includes instructing participants to draw a cycle to be a clock, then to add the numbers appropriately and finally to set the time to 11.10. In this study, Shulman method was used to evaluate CDT, since it is accepted to be one of the most commonly used scoring systems (9). According to the Shulman method, the score ranges between 0 and 5 with the highest score being 5. Zero point means there is no representation of a clock, 1 point is given for a severe disorganization of numbers which do not represent a clock, 2 point is given for moderate disorganization, 3 point is given for acceptable organization with inaccurate hands, 4 point is given for minor organizational errors, and 5 point stands for the well-organized numbers with hands accurately placed.

Trail Making Test (TMT):

Trail Making Test (TMT) is a well-known neuropsychological test to measure executive functions. It consists of two parts as part A and part B. In both parts, participants are given a sheet of paper where they are instructed to connect 25 circles. In part A, circles only include numbers from 1 to 25 and participants are required to draw a line to connect them in an ascending pattern. In part B, circles include both numbers (from 1 to 13) and letters (from A to ..) and participants are required to connect them in an

alternating pattern (e.g. 1-A-2-B-3-C etc.). The completion time of both parts as well as the number of errors were recorded. The normative data of TMT for the Turkish older population was reported by Cangöz et al. (10).

Mini Mental State Examination (MMSE):
The MMSE is a widely used bedside test to screen mental state, consisting of subdomains measuring orientation, registration, attention, recall and language (11). The Turkish version of MMSE was standardized by Gungen et al. (12). The maximum score of MMSE is 30.

Statistical Analyses
For assessing the normality of data, skewness and kurtosis of the distribution were checked. Since the scores were found to fall within the normal range (-1.5 - +1.5 for the skewness and -3 - +3 for the kurtosis), parametric analyses were performed. Independent samples t-test was used to examine group differences in executive function performance. Pearson correlation analyses were applied to examine the relationship between executive function tests as well as sociodemographic variables. All statistical analyses were performed using SPSS version 24 (SPSS Inc., Chicago, IL, USA) and the significance level was set at p<.05; two-tailed for all analyses.

Results

The mean age of COVID-P group (n: 22) was 76.95±6.6 and the mean education year was 11.45±3.2. The mean age of COVID-N group (n: 25) was 74.16±5.01 and the mean education year was 12.44±3.44. An independent sample t-test revealed that there was no significant difference between the COVID-P and COVID-N group in terms of age and education (p>.05 for both). The gender distribution among the groups was also normal (p>.05).

The independent t-test showed that neither the total MMSE score nor the subscores were statistically different between COVID-P and COVID-N group (p>.05 for all). The MMSE scores for both groups and significance levels were presented in Table 1.

Regarding the executive function tests, test completion time for TMT-A was significantly longer for COVID-P group as compared to COVID-N group [t(44)= 2.126, p < .039]. The test completion time for TMT-B was also significantly longer for COVID-P group [t(44)= 1,894 p< .045]. In addition, the number of errors in TMT-A was significantly higher for the COVID-P group than the COVID-N group [t(44)= 1.990, p< .041]. However, groups did not have a significantly different performance on CDT (p> .05).

Table 1. Mean scores of cognitive tests for each group

	COVID-P group M±SD.	COVID-N group M±SD.	Significance level
MMSE total score	26.7±2.14	27.72 ±1.02	NS
Orientation	9.40± .73	9.64± .56	NS
Registration	2.81± .5	2.84± .37	NS
Attention	3.54±1.22	4.08±.90	NS
Recall	2± .75	2.28± .61	NS
Language	8.72± .55	8.84± .37	NS
TMT-A completion time	173.644±42.42	110.32±64.17	.039
TMT-B completion time	382.05± 101.62	265.80± 115.14	.045
TMT-A error	1.18± 1.4	.56±.65	.041
TMT-B error	4.27±3.23	3.4±3.2	NS
CDT score	4.36 ± .84	4.24± .87	NS

MMSE: Mini mental state examination, TMT: Trail Making Test, CDT: Clock Drawing Test NS: Nonsignificant

As expected, there was a positive correlation between age and test completion time for TMT-A (r=.424, p<.001), test completion time for TMT-B (r=.482, p<.001), and the number of errors for TMT-B (r=.508, p<.001). Also, age was found to be negatively correlated with CDT performance (r= -.589, p<.001). Education year, however, was not found to be correlated with any of the test scores (p>.05, for all).

In order to clarify if age had a moderator effect on the relationship between COVID-19 condition and executive functions, we performed a moderation analysis using PROCESS (Model 1). The outcome variables were completion time for TMT-A and completion time for TMT-B, respectively. The analysis showed that the interaction between COVID-19 group and age was not statistically significant for the TMT-A completion time, b= .0044, t(47)= -.4973, p= .62. Similarly, the interaction between COVID-19 group and age did not statistically contribute to the TMT-B completion time, b= .0025, t(47)= -.3807, p= .70.

Discussion

It is a well-known fact that brain aging is often associated with cognitive decline. Since the role of previous viral infections on cognitive decline has been widely discussed in the literature, currently, there is a growing interest among researchers to study the neurocognitive effects of COVID-19. Given that the older population is assumed to have a greater risk for COVID-19, its effects on mental health should be noticed. In this study, we compared executive functions in older adults who experienced COVID-19 infection in the last 6 months with another group of older adults who did not infected by the virus. Accordingly, the present study provided one of the first pieces of evidence for the negative impact of COVID-19 on executive functions in older adults. Namely, the COVID-P group displayed significantly lower performance on TMT, which is considered to be one of the most widely used and reliable tests to evaluate executive functions.

Since neurological manifestations are shown to be notably common in patients with COVID-19, the presence of acute cognitive complaints should not be surprising (13). However, while there is preliminary evidence of post-infectious cognitive decline, long-term cognitive consequences are still not well established in the literature. Recently, Liu et al. (14) reported that both severe and non-severe COVID-19 survivors experienced cognitive difficulties and almost 60% of severe COVID-19 survivors displayed longitudinal cognitive decline. In another study, executive dysfunction, apathy and cognitive fatigue were reported in people following COVID-19 infection (15).

A limited number of studies also suggested worsening of cognitive functions in people with dementia after being infected by COVID-19 (16). Likewise, older adults with dementia were shown to be more likely to experience COVID-19 in a more severe form, including increased risk of death (17). In an extensive meta-analysis, it was reported that the risk of being infected by COVID-19 is significantly higher in patients with dementia as compared to healthy controls (18). Therefore, identification of the bidirectional link between COVID-19 and dementia during pandemic is crucial to minimize the risk of infection in older adults.

Increasing evidence suggests that COVID-19 has an impact on the central nervous system. Although the exact mechanism underlying its effect on brain structure and function has not been clearly elucidated, some potential causes have been reported (15). Firstly, a considerable amount of evidence suggests hypoxia as the major cause, since prolonged oxygen deficiency is known to damage neurons. Researchers revealed that even silent hypoxia, where the patients do not experience any covert breathing difficulty despite insufficient oxygen saturation level, may induce damage to the brain (19). Accordingly, both structural and metabolic changes in the brain are linked to COVID-19 in the literature. Namely, studies reported frontotemporal hypoperfusion as well as structural abnormalities in temporal regions in COVID-19 survivors (19-20). In an animal study conducted with mice, reduced hippocampal volume following COVID-19 was observed, which is well known as a critical brain region for attention and memory processes (21).

In addition to direct effects of COVID-19 on the brain, researchers suggest the existence of multiple contributing factors (22). For example, in one study, increased depressive symptoms and anxiety has been related to cognitive complaints in patients who recovered from COVID-19.1 Additionally, Amanzio et al. (23) reported lockdown fatigue as an indirect contributor to poorer cognition by altering mood in a negative way. A recent study in Turkey aimed to examine the traumatic effect of COVID-19 on mental health and reported COVID-19 as a severe trauma directly or indirectly affecting executive functions (24). However, their measure of executive function was based on participants' self-reports. Neuropsychological evaluation is essential to verify COVID-19 survivors' executive function performance, as in our study.

Lack of brain imaging data might be listed as the foremost limitation of this study. Since our findings solely rely on the neuropsychological assessment, it is required to enlighten the possible underlying neurological basis of the deficit. Second most important limitation of the study is the relatively small sample size. Finally, since the principal goal of this study was to examine whether COVID-19 has a deteriorative effect on executive functions, we only included relevant instruments to measure participants' executive test performance. However, application of a wider neuropsychological battery might shed light on COVID-19-dependent cognitive decline in older adults. Therefore, future studies with larger sample sizes combined with structural or functional neuroimaging data are still required to better understand the association between COVID-19 and cognitive decline.

Conclusion

In this study, it was aimed to determine the role of COVID-19 on the executive functions in older people. Accordingly, we compared the executive function performance of a group of older people living in a nursing home who were previously infected by COVID-19 and who were not infected. In summary, we demonstrated that executive functioning in older adults who were previously infected by COVID-19 was lower as compared to those who were not infected. Given that the sample of this study was comprised of elderly with normal cognition, whose executive functions were found to be linked to their history of COVID-19, exploring the possible effects of this virus on people having cognitive decline should be noteworthy in order to help elderly to maintain a more successful aging.

Declarations

Funding

No financial support was received for the study.

Conflicts of Interest

No potential conflict of interest was reported by the authors.

Ethics Approval

The study was approved by Uskudar University Non-Interventional Research Ethics Committee, report number of 61351342/07/2021-30 (29 July 2021).

Availability of Data and Material

The dataset of this study are available from the corresponding author on a reasonable request.

Authors Contributions

Both authors contributed equally to all parts of the study.

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