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Original article

The Effects of COVID-19 Restrictions on Dietary Behaviors, Supplement, and Physical Activity Habits of Children with Autism Spectrum Disorder

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Abstract. *Study Objectives:* Limited studies show that adverse behavioral outcomes such as physical activity (PA), Dietary Behaviors (DB) are increasing among children with autism spectrum disorder (ASD) because of COVID 19. However, the effects of the pandemic on children with ASD are little known. This study aimed to evaluate the factors that may affect the PA, DS, and DB of individuals with ASD before and during the curfew brought by the COVID-19 epidemic. *Methods:* A total of 64 ASD participants (40 boys and 24) girls aged 6-18 years, were included in the study. The mean age of the participants was (13.75 ± 1.67). An online questionnaire consisting of sociodemographic data, PA, DS, and DS habits was applied to the participants. *Results:* BMI (kg/m^2) increased compared to pre-COVID-19 (< 0.001). It was determined that the physical activity levels of the participants with ASD were greatly reduced compared to pre-COVID-19 (<0.001). Duration of PA conducted 1 time a week, 3 times a week, and >7 days/week were found to be <30 minutes (< 0.001). Compared to pre-COVID-19, breakfast habits were changed (71.9%; < 0.001). Eating and snacking although not feeling hungry increased, (< 0.310; < 0.120 respectively). Vitamin C (53.1%), vitamin D (70.3%), vitamin B12 (50.0%), Calcium (75.0) and Magnesium (67.1%) use was determined to increase significantly (< 0.001) in participants with ASD during COVID-19. *Conclusion*: It was determined that individuals with ASD have significant decreases in physical activity, and nutritional behavior and significant increases in supplement use during the COVID-19 epidemic.

Key words: COVID-19, autism, supplementation, physical Activity, dietary behaviors

Introduction

The coronavirus (COVID-19) pandemic has posed significant problems to human health because of the virus, as well as the restrictions imposed by governing bodies to encourage the reduction of the risk of transmission. Previous research on the worldwide COVID-19 pandemic; showed that significantly greater effects were experienced by people with psychiatric and mental health disorders (e.g., Autism Spectrum Disorder (ASD)) compared to the general population (1). Although the measures taken to combat the epidemic have contributed to many people staying at home around the world, this has led people to a sedentary life at home (2,3). Education programs for children with developmental disabilities who received special education at home, school, hospital, or rehabilitation centers of previously physically active individuals, such as ASD, were suddenly interrupted due to the epidemic (4,5). These changes in the daily routines of children with ASD due to COVID-19 have revealed risks that affect different perspectives on their lives.

Those with ASD represent a particularly vulnerable population. These individuals often prefer

to follow structured routines with particular preferences regarding foods and eating environments. The wide-ranging changes brought about by the pandemic can only be expected to be acutely devastating, as minor disruptions can lead to increased stress and anxiety in children with neurodevelopmental disorders (6). In addition to delays in motor development due to the COVID-19 pandemic, individuals with ASD have been shown to have deficiencies in motor skills, lack of participation in daily activities, and decreased motivation to participate in beneficial physical activity (PA) (7). As stated by WHO, people with ASD constitute a special risk group due to their sedentary lifestyles that increase the risk of chronic diseases such as diabetes, obesity, and heart disease (8,9). This is because children with ASD have fewer opportunities to participate in physical activity and exercise, putting them at risk of developing other health problems. Studies show that children with ASD have lower physical activity (PA) levels than individuals with normal development (10).

Before COVID-19, individuals with ASD were already at risk for malnutrition intake and health consequences, mainly due to greater food selectivity, a lack of a diverse diet, and poor gut health (11). According to a study, COVID-19 is exacerbating these challenges, particularly among families with low household incomes and/or household food insecurity situations. These findings, combined with the known nutritional deficiencies present in some children with ASD before the pandemic, highlight the importance of monitoring the unique needs of this high-risk population and tailoring public health responses to ASD families with fewer resources (1). Recently, an increase in the use of dietary supplements (DS) and the consumption of herbal products has been observed in many developed and developing countries. For example, the evidence for the usefulness of D among COVID-19 patients is stronger than for other micronutrients. Recent observations showed that those with vitamin D deficiency are 1.77 times more likely to test positive for COVID-19 (12). In addition, an ecological study showed that certain nutrients are of higher interest for COVID-19 patients, most notably vitamins D, C, B12, and iron are associated with a lower incidence and/or mortality of COVID-19 (13). Consumers in the US have tended to increase their consumption of these DS by 10-15% since the COVID-19 pandemic began, and about 20% of non-user of supplement users reported an expected tendency to use DS over the next three months (14).

According to this study, in addition to weaker nutritional status in individuals with ASD, the absence of preferred foods is likely to cause emotional distress for all involved and increase the burden on caregivers and families (15). For example, 55% of those surveyed reported a decrease in the child's physical activity, in addition, they reported that children ate more sweets and less vegetables and meat. A recent study among adults found that self-quarantine during COVID-19 led to stress eating and reduced physical activity, both of which are risk factors for weight gain. Showed that >26% of the children in the study were reported as obese (16). Given the importance of dietary habits, daily supplementation, and PA behaviors in adolescents with ASD, it is critical to determine whether they would be affected by the pandemic. Therefore, this study aimed to evaluate the factors that may affect the PA, DS, and DB of individuals with ASD before and during the curfew brought by the COVID-19 epidemic.

Material and Method

Participants and Study Design

This is a cross-sectional study, conducted between 15 June 2021 and 31 December 2021. The study was based on a structured, validated questionnaire created using Google Form. The questionnaire was sent to the mothers of children with ASD using only convenience and snowball sampling techniques via WhatsApp and Facebook Messenger, and parental permission/permission was obtained. After the data obtained from the questionnaires were collected, the forms were verified by making comparisons, and the forms containing incorrect or incomplete information or contradictory information were excluded from the study. Totally, 64 children with ASD were included in the study. The criteria for inclusion in the survey used in the study process were being 6-18 years old and

diagnosed with ASD. After the data obtained from the questionnaires were collected, forms were verified by making comparisons, and the forms containing incorrect incomplete, or contradictory were excluded from the study. An online questionnaire consisting of sociodemographic data, nutritional behaviors, daily and weekly supplement (DS) use, and physical activity habits was administered to individuals with ASD. Respondents were asked to answer questions from the self-administered online questionnaire (completed in less than 5 minutes) and were informed that they could stop answering these questions at any time without obligation to justify the decision. The work was carried out in accordance with the Declaration of Helsinki and the current privacy law and the data were processed (EU Regulation 2016/679 and Privacy Code D.Lgs. 101/2018). No formal approval was requested from the ethics committee as we were conducting an anonymized survey online.

Collection of Data

Socio-demographic data was prepared as age, gender, current weight, height, and BMI before and during COVID-19. In the section on nutritional behavior, nutritional habits before and during COVID-19, increased food consumption compared to before quarantine, fruit, and vegetable consumption during quarantine, increased fast food consumption compared to before quarantine; having breakfast, eating without hunger, frequency of snack consumption during the day were asked. In terms of regular physical activity parents of children with ASD were determined according to the answer given to the question "How many days did this child exercise did sports or participated in physical activity for at least 60 minutes in the last week". Responses varied on a 4-point scale ("never", "1 day", "3 days" and "every day"). A dual classification of "regular physical activity" was defined as "daily" consistent with physical activity recommendations for adolescents (18). Participants with ASD were asked about their estimated intake of supplements. Regarding the daily/weekly supplement use, multivitamins were focused on vitamin C, vitamin D, vitamin B12, Calcium, and Magnesium.

Self-Reported Anthropometric Measurements

Participants self-reported their weight and height, and their body mass index (BMI) was calculated. BMI Z-scores for age and height Z-scores for age were calculated. For the association of the BMI-for-age with overweight and obesity, values > +1 standard deviation (SD) represent overweight (equivalent to BMI 25 kg/m2 at 19 y) and > +2 SD represent obesity (equivalent to BMI 30 kg/m2 at 19 y) according to the WHO reference curves (2007). Values between +1 SD and -2 SD were considered normal, values >-2 and -3 were considered weak, and values between -3 SD were considered very weak, respectively. Regarding height, children were classified into the following categories: stunted (low height < -2 Z-scores), < -3.00 was defined as severely stunted, and values above -2 SD were considered normal height (17).

Statistical Analysis

Continuous variables were given as mean (standard deviation (SD), and categorical variables as frequency and percentage. Factors associated with physical activity levels (increase, similarity, decrease), daily and weekly supplement use, and dietary habits before/during COVID-19 were examined by the Chi-square test. Univariate comparisons between groups and variables were investigated using the Fisher exact test for categorical data or the non-parametric Wilcoxon rank-sum test when appropriate for continuous data. A 95% confidence interval was applied, and the significance level was previously determined as 5% ($p < 0.05$) was considered significant.

Results

Sociodemographic characteristics of individuals with ASD are presented in Table 1. Females represented 37.5% (n=24) of the study population, while 62.5% (n=40) were males. The average mean age of the overall sample population was 13.75 ± 1.67, males (14.30±1.75), and females (13.20±1.60). Before COVID-19 nearly half of participants (50.0%, n = 32) had normal self-reported body mass index (BMI),

Table 1. Comparison of socio-demographic characteristics of the ASD participants overall by gender.

Characteristics	Total n = 64	Female n = 24	Male n = 40	p-Value
Age (y)	13,75 ± 1,67	13.20 ± 1.60	14.30 ± 1.75	< 0.05
Weight (kg) before COVID-19	64.8 ±11.8	62.2 ±11.2	67.4 ±12.4	< 0.01
Current weight (kg)	69.3 ±12.9	65.4 ±12.6	73.2 ±13.3	< 0.01
Height (cm)	168.8±7.4	165.6 ±6.4	172.0 ±8.5	< 0.01
BMI (kg/m^2) before COVID-19				
Underweight [a]	6 (%9,3)	2 (%8.3)	4 (%10.0)	< 0.01
Normal [b]	32 (%50.0)	12 (%50.0)	20 (%50.0)	
Overweight [c]	16 (%25.0)	6 (%25.0)	10 (%25.0)	
Obese [d]	10 (%15.7)	4 (%16.7)	6 (%15.0)	
BMI (kg/m^2) during COVID-19				
Underweight [a]	5 (%7.8)	2 (%8.3)	3 (%7.5)	< 0.001
Normal [b]	19 (%29.7)	7 (%29.2)	12 (%30.0)	
Overweight [c]	25 (%39.1)	9 (%37.5)	16 (%40.0)	
Obese [d]	15 (%23.4)	6 (%25.0)	9 (%22.5)	

Body Mass Index (BMI), [a] values >-2 and -3 were considered weak, [b] Values between +1 SD and -2 SD were considered normal, [c] values > +1 standard deviation (SD) represent overweight (equivalent to BMI 25 kg/m2 at 19 y), [d] > +2 SD represent obesity (equivalent to BMI 30 kg/m2 at 19 y)

25.0% (n = 16) were overweight, 15.7% (n = 10) were obese, respectively. While there was a decrease in the self-reported normal body mass index (29.7%, n = 19) of the participants after COVID-19, significant increases were detected in the overweight 39.1% (n = 25) and obese 23.4% (n = 15) (< 0.001). The rate of being obese among ASD women was determined to be higher than in men (Table 1).

Compared to pre-COVID-19, 3 or more meals a day were consumed (28.1%; < 0.120), and the consumption rate in women with ASD was higher than in men. It was determined that total fruit consumption (39.1%) increased, while (40.6%) remained unchanged (< 0.030) during the quarantine period. The increase in fruit consumption was found to be higher in men with ASD. More meals were cooked at home (45.3%; < 0.173) than pre- COVID-19. Compared to pre-COVID-19, it was determined that the consumption of ready meals increased in men and women with ASD. Breakfast habits were found to be changed compared to pre-COVID-19 (71.9%; < 0.001). Eating and snacking although not feeling hungry, behaviors increased, respectively (< 0.310; < 0.120) (Table 2).

It was determined that participants with ASD consumed more supplements than before COVID-19 (< 0.001). It was determined that before the quarantine (respectively; vitamin C (42.3%), vitamin D (31.2%), vitamin B12 (23.4%), Calcium (45.3), and Magnesium (46.8%)) were not used at all. During COVID-19; (respectively; vitamin C (53.1%), vitamin D (70.3%), vitamin B12 (50.0%), Calcium (75.0) and Magnesium (67.1%)) use was determined to increase significantly (< 0.001). Compared to pre-COVID-19, the fastest increase in supplement use was in daily use, while there was a significant decrease in the rate of those who never used it (Figure 1).

It was determined that the physical activity levels of the participants with ASD were greatly reduced compared to pre-COVID-19 (<0.001). It was determined that 20.8% of women with ASD and 10.0% of men with ASD did not do any PA per day/week before COVID-19. However, it was determined that in the COVID-19 process 62.5% of women and 67.5% of men never did PA. Compared to pre-COVID-19; 1 time a week, 3 times a week, and >7 days/week PA duration of participants with ASD were found to be

Table 2. Change in eating habits of participants with ASD before and during the pandemic period the initiation of COVID-19 regulations

Characteristics	Total n = 64	Female n = 24	Male n = 40	p-Value
How were your eating habits before COVID-19?				
2 meals a day	23 (%36.0)	9 (%37.5)	14 (%35.0)	< 0.130
3 meals a day	29 (%45.3)	11 (%45.9)	18 (%45.0)	
3 or more meals a day	12 (%18.7)	4 (%16.6)	8 (%20.0)	
How was your eating habits during COVID-19?				
2 meals a day	12 (%18.8)	4 (%16.7)	8 (%20.0)	< 0.120
3 meals a day	34 (%53.1)	13 (%54.2)	21 (%52.5)	
3 or more meals a day	18 (%28.1)	7(%29.1)	11 (%27.5)	
Has your fruit consumption changed during the COVID-19?				
Increased	25 (%39.1)	8 (%33.3)	17 (%42.5)	< 0.030
Decreased	13 (%20.3)	6 (%25.0)	7 (%17.5)	
Not changed	26 (%40.6)	10 (%41.7)	16 (%40.0)	
How was your food consumption habits compared to the period before COVID-19?				
Normal	14 (%21.9)	6 (%25.0)	8 (%20.0)	< 0.173
More home cooking	29 (%45.3)	10 (%41.7)	19 (%47.5)	
More ready meals	21 (%32.8)	8 (%33.3)	13 (%32.5)	
Did your breakfast habits change during the COVID-19?				
Yes	46 (%71.9)	18 (%75.0)	28 (%70.0)	< 0.001
No	18 (%28.1)	6 (%25.0)	12 (%30.0)	
How often do you eat during the day, even though you are not hungry?				
Every meal	12 (%18.6)	5 (%20.8)	7 (%17.5)	< 0.310
1-2 times / A Day	9 (%14.1)	3 (%12.5)	6 (%15.0)	
3-4 times / A Day	24 (%37.5)	9 (%37.5)	15 (%37.5)	
Sometimes	14 (%21.9)	6 (%25.0)	8 (%20.0)	
Never	5 (%7.9)	1 (%4.2)	4 (%10.0)	
How often do you eat an appetizer in the COVID-19 process?				
Every meal	20 (%31.2)	7 (%29.2)	13 (%32.5)	< 0.120
1-2 times / A Day	12 (%18.7)	4 (%16.7)	7 (%17.5)	
3-4 times / A Day	20 (%31.2)	8 (%33.4)	12 (%30.0)	
Sometimes	9 (%14.2)	4 (%16.7)	5 (%12.5)	
Never	3 (%4.7)	1 (%4.2)	3 (%7.5)	

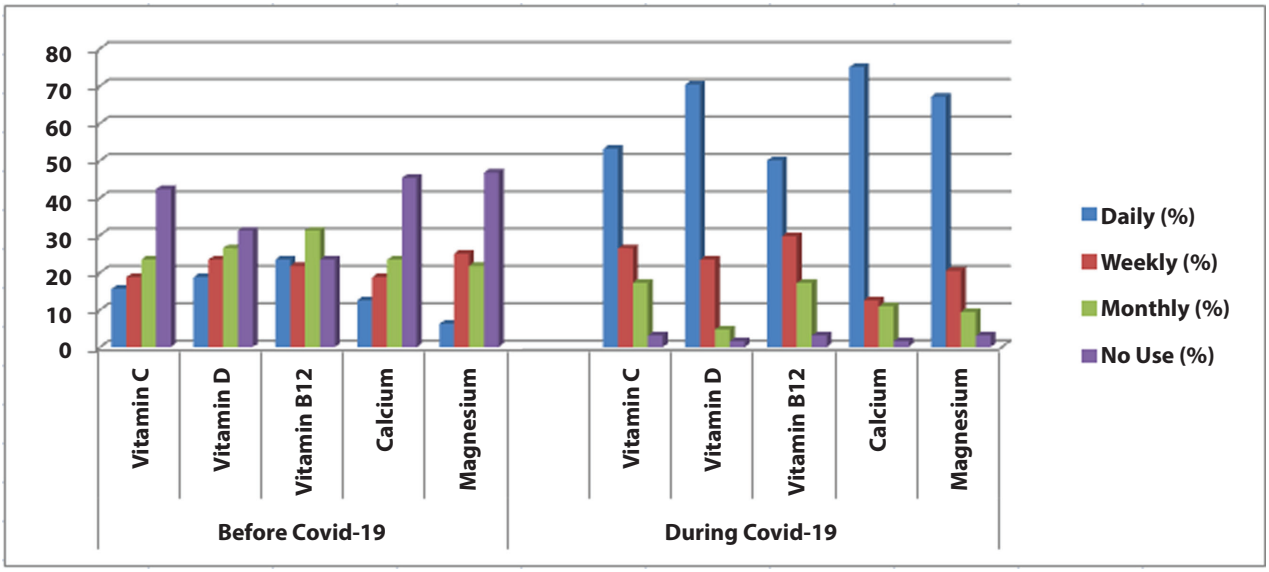

Figure 1. Comparison between the daily, weekly, monthly, and never use of supplements before and during the COVID-19 pandemic.

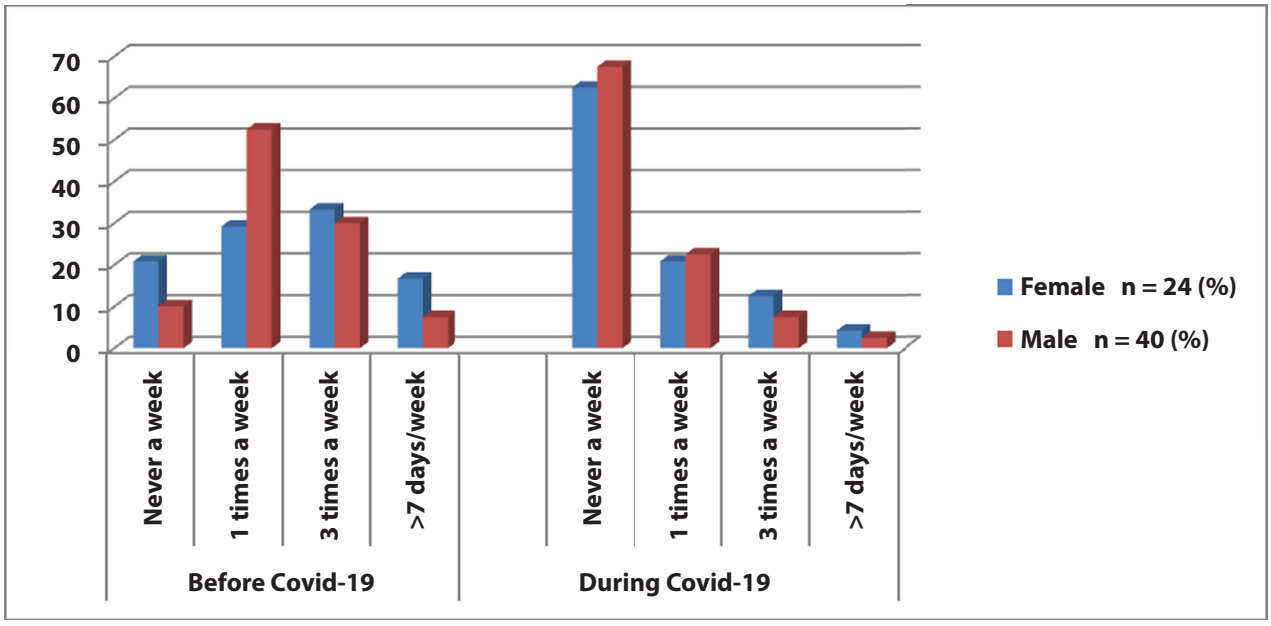

Figure 2. Comparison between the physical activity frequency days/week before and during the COVID-19 pandemic.

less than <30 minutes (< 0.001) (Figure 2). As seen in Graph 2, the rate of those who did PA once a week before COVID-19 was 29.2% in women with ASD, while it was 52.5% in men. However, it was observed that conducting PA during the COVID-19 process decreased considerably.

Discussion

The COVID-19 pandemic has led to population lockdown around the world, particularly among individuals with ASD. Numerous scientific studies have been conducted to evaluate its effect on individual

activity behavior during and after quarantine. As a result, dietary behavior disorders explained the increase in supplement use and the overall decrease in levels of physical activity habits. The COVID-19 pandemic is often an unpleasant experience for those suffering from quarantine. The reason for this was that social distancing, closing schools, banning group gatherings, and restricting physical activity suddenly turned the traditional lifestyle upside down (19). In this study, it was found significant differences in participants' age, weight, height, and BMI before and during COVID-19. Especially during the quarantine period, both women and men gained weight. During the COVID-19 process, it was determined that the participants were overweight and obese. Compared to pre-COVID-19, participants' self-reported normal body mass index decreased by 29.7%, while significant increases were detected at 39.1% for overweight and 23.4% for obese. The rate of being obese was found to be higher in women with ASD than in men. According to a study (20), the probability of being overweight and obese was 33.3% for adolescents with ASD compared to their normally developing peers, while the probability of being obese was 21.4% for women and 25.1% for men. These results were consistent with previous research showing that people with ASD are more likely to be overweight or obese compared to their typically developing peers (21, 22, 23). Therefore, this predisposition to weight gain, COVID-19-imposed conditions, such as self-isolation and lack of food, may disproportionately affect the weight status of individuals with ASD.

According to the findings of this study compared to pre-COVID-19, 3 or more meals were consumed per day, the consumption rate was higher in women with ASD than in men. It was determined that total fruit consumption increased during the quarantine. The increase in fruit consumption was higher in men with ASD. While more food was cooked at home than before COVID-19, it was determined that the consumption of ready meals increased in men and women with ASD compared to pre-COVID-19. An increase was observed in eating and snacking although not feeling hungry. Those with autism spectrum disorder (ASD) represent a particularly vulnerable population. These individuals often prefer to follow structured routines with certain preferences, especially regarding their eating behavior. Thus, the eating behavior patterns of individuals with ASD deteriorated during the COVID-19 outbreak (e.g., number of main meals or snacks between meals, uncontrolled eating, or type of food) (24). However, there is currently a lack of focus on how changes in dietary habits and their environment due to COVID-19 affect individuals with ASD in particular. Before COVID-19, individuals with ASD were already at risk for malnutrition intake and health consequences, mainly due to greater food selectivity, and lack of a diverse diet (25). This shows that COVID-19 increases these risks, especially among families with ASD. In a study, it was revealed that 28% of ASD families reported that they had more difficulty in managing meals compared to before the pandemic (26). However, this may suggest that the pandemic has more severe effects on mealtime patterns and eating behaviors among ASD families. In conclusion, disruption in eating behaviors with COVID-19 is associated with adverse effects on the immune system, which can exacerbate ASD symptoms and co-occurring conditions, including hyperactivity. This unfortunate situation perpetuates existing problems, possibly placing greater burdens on individuals with ASD.

The COVID-19 pandemic has intensified the current struggles faced by individuals and families with ASD. This exacerbated development of children with ASD and other developmental disorders after the onset of the pandemic than before the pandemic (27). Therefore, individuals with ASD are more likely to be chronically malnourished. The specific nutrient deficiencies in these cases overlap with those experienced by many children with ASD (i.e., vitamins A and D, iron, zinc, and selenium) (28, 29). Many of these nutrients act as antioxidants. As a result, unhealthy eating habits can lead to obesity, diabetes and other chronic and inflammatory metabolic conditions that individuals with ASD are at higher risk (30). According to findings, it was determined that the use of vitamin C, vitamin D, vitamin B12, Calcium, and Magnesium has increased significantly in the COVID-19 process according to the participants with ASD before COVID-19. Compared to pre-COVID-19, the fastest increase in supplement use was in daily use, while there was a serious decrease in the rate of those who never used it. In one study, when asked about the

treatment followed by those who admitted to contracting COVID-19, more than half of the respondents reported that 57.6% used either vitamin C or vitamin D or zinc supplement products.

The highest percentage was for those who took vitamin C supplements during their infectious period. This is because in previous trials, vitamin C has been shown to affect pneumonia (27). The percentage of respondents who believe the use of supplements is important for health and to support their immunity has increased significantly during the pandemic. But COVID-19 has also reduced the general population's confidence in the ability of food nutrients to adequately support health. According to the findings of this study, it was determined that more than half of the participants with ASD used supplements during the pandemic, which was considered significant. However, the study findings showed that there was a significant increase in participants' use of supplements during COVID-19. According to a study, a significant increase in weekly and daily intake of antioxidants, vitamin C, vitamin D, vitamin E, calcium, and zinc was observed during COVID-19. This is due to the belief that these nutrients have proven abilities to strengthen the immune system, have an antiviral effect, are antioxidants, and are characterized by anti-inflammatory effects (31). Consequently, the use of supplements may provide therapeutic support against COVID-19. But, due to the lack of evidence regarding the link between days of supplement use and prevention of COVID-19 infection and World Health Organization guidelines, there is a need to design and implement robust clinical trials to enable the use of these supplement products among COVID-19 patients (32). As noted by the European Food Safety Authority (EFSA), the six vitamins (D, A, C, Folate, B6, B12) and four minerals (zinc, iron, copper, and selenium) are the most promising for COVID-19 management. These were shown to have stronger benefits in the prevention, treatment, and management of COVID-19 symptoms (33)

Children with ASD are at risk of physical inactivity due to social and behavioral problems. While these individuals display more deficient motor skills and physical condition than normally developing children, they tend to spend less time on physical exercise. Physical inactivity is an ongoing global health problem. During the COVID-19 pandemic, increased physical inactivity and sedentary behaviors in both normal and ASD children have been associated with increased weight gain in children and adolescents (3). According to a study, 55% of the participants reported a decrease in their child's physical activity, and the children consumed more sweets and fewer vegetables and meat. It was found that self-quarantine during COVID-19 led to stress eating and reduced physical activity, both of which are risk factors for weight gain (34). According to the findings of this study, it was determined that the physical activity levels of the participants with ASD were greatly reduced compared to pre-COVID-19. However, it was determined that during the COVID-19 process 62.5% of the women and 67.5% of the men had never done PA. Compared to pre-COVID-19 once a week, 3 times a week, and >7 days/week, PA levels of participants with ASD were found to be less than <30 minutes. In individuals with ASD, it was observed that the state of doing FA during the COVID-19 process decreased considerably. Some studies have found that individuals with ASD typically spend less time in moderate-to-vigorous physical activity than their normal peers. On the other hand, it was suggested that people with ASD are less physically active and engage in moderate-to-vigorous physical activity for a shorter time compared to their normally developing peers. The COVID-19 pandemic may adversely affect the health behavior of youth with ASD and appears to increase sedentary behavior due to quarantine while serving as a potential barrier to participation in PA (35, 36). This supports the hypothesis that adolescents with ASD are more likely to be overweight or obese and less likely to engage in physical activity behaviors. However, the results of that study do not support the hypothesis of this study that adolescents with ASD would be more likely to engage in sedentary behaviors. Individuals with ASD were less likely to engage in regular weekly physical activity. The findings of this study are consistent with previous research examining physical activity behaviors in this population.

Conclusion

As a result, the COVID-19 pandemic has brought great challenges to all aspects of health. However, vulnerable populations, including those with ASD and

other neurodevelopmental disorders, are disproportionately at risk for adverse outcomes. Considering the results, it is suggested that individuals with ASD face moderate to major effects on their eating behavior, physical activity, and supplement use. These findings suggest that the pandemic has a reinforced impact on disadvantaged individuals with ASD, and further research is warranted in the future. It is also the first study to provide evidence that individuals with ASD may experience significant decreases in physical activity, nutritional behavior, and significant increases in supplement use during the COVID-19 pandemic. Because the duration of the pandemic is unknown, it is critical to understand the effects of COVID-19 on the health behaviors of individuals with ASD so that effective strategies can be developed to reduce the negative impact and protect against potential long-term health risks.

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