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RELATIONSHIP BETWEEN PHYSICAL ACTIVITY, HAND GRIP STRENGTH, AND MALNUTRITION STATUS IN NEURODEGENERATIVE DISEASES: A CASE-CONTROL STUDY

Güleren Sabuncular*[1], Ayşe Hümeyra İslamoğlu[1], Şimal Bektaş[1], İremnur Menevşe[1], Sümeyra Nurcan Taş[1], Şule Aktaç[1]

[1]Marmara University, Faculty of Health Sciences, Department of Nutrition and Dietetics, Istanbul, Turkey.

ORCID iD: Güleren Sabuncular: 0000-0001-5922-295X; Ayşe Hümeyra İslamoğlu: 0000-0002-2138-5996; Şimal Bektaş: 0009-0004-8074-5244i; İremnur Menevşe: 0009-0008-2378-5599; Sümeyra Nurcan Taş: 0009-0003-2543-1229; Şule Aktaç: 0000-0002-2158-5015

***Corresponding Author:** Güleren Sabuncular, **e-mail:** gulerenserin@hotmail.com

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Abstract

Objective: To determine the relationship between physical activity level, hand grip asymmetry, and nutritional status in geriatric individuals with and without neurodegenerative diseases.

Methods: This research was conducted in a nursing home in Istanbul between November 2023 and March 2024. The study included geriatric individuals aged 65 years and older with neurodegenerative diseases as the study group and age-matched controls with no evidence of neurodegeneration. Data collection involved sociodemographic surveys, anthropometric measurements, hand grip strength measurements, International Physical Activity Questionnaire and Mini Nutritional Assessment tests.

Results: The mean age of study group was 76.7±7.3 and 74.3±7.5 years in control group. The study group had a higher malnutrition risk (59.3%) compared to controls, who showed predominantly normal nutritional status (66.7%, p=0.031). Hand grip strength measurements revealed greater asymmetry in the study group (74.1% vs. 33.3% with no asymmetry, p=0.003), along with significantly lower mean hand grip strength values on the right (13.3±6.4 vs. 22.1±7.6) and left hand (12.4±6.3 vs. 21.0±7.2, both p<0.001). The median hand grip strength ratio was also lower in the study group (0.8 [0.7-0.8] vs. 1.0 [0.9-1.0], p<0.001). In minimally active participants, neurodegenerative disease strongly correlated with increased hand grip strength asymmetry (87.5% vs. 29.2%, p<0.001), while no significant asymmetry association was observed in inactive individuals (p=0.707).

Conclusion: Handgrip strength and its asymmetry may offer promise for early detection and monitoring of neurodegenerative diseases in older adults. We propose that these tests be incorporated into geriatric clinical assessments to improve early intervention strategies.

Keywords*: Geriatrics, handgrip strength, neurodegenerative diseases, nutritional status, physical activity.*

Introduction

According to the 2017 data of the Turkish Statistical Institute, the ratio of the elderly population to the total population increased from 8.5% in 2017 to 9.9% in 2022.[1] Geriatric individuals experience various physiological and motor changes that increase the risk of age-related diseases and disabilities.[2] Recent evidence has shown that age-associated changes (risk factors) are divided into modifiable and unmodifiable groups. The unmodifiable factors are age and genetic, while modifiable factors are obesity, smoking, and physical inactivity.[3] Specifically, physical activity was consistently found to enhance cognitive performance, increase mobility, and improve balance and daily living activities, contributing to a better quality of life.[4] As age progresses, cognitive function may deteriorate, and this can intensify and be associated with neurodegenerative diseases. Individuals with neurodegenerative disorders usually experience a long asymptomatic period before diagnosis. However, by the time the diagnosis is confirmed, serious and irreversible damage to the nervous system may have occurred.[5] Dementia, a neurodegenerative disease, is a serious health problem in which prevalence increases with aging, and the most common of all types of dementia is Alzheimer's disease.[6] In addition to cognitive impairment in Alzheimer's, decreases in the performance of other systems, such as fatigue, slow walking, and decreased muscle strength are also observed, and these non-cognitive features may be early determinants of cognitive impairment.[7]

In geriatric individuals with neurodegenerative diseases, progressive dysfunction due to neurological complications may also cause malnutrition. While movement limitations and motor dysfunctions in individuals restrict food intake, severe dysphagia may occur in the course of these diseases. In addition, depression, deterioration of self-care, difficulty swallowing and medications may also be involved in the etiology of malnutrition that develops with these diseases.[8,9] Hand grip strength (HGS) is accepted as an objective criterion of the functional integrity of the upper extremity, provides convenience and objectivity in the evaluation of treatment, and also ensures the preservation of functional autonomy in daily life.[10] Low handgrip strength is a reliable marker of muscle dysfunction and a strong indicator of declining health.[11] While decline in handgrip strength is primarily considered an age-related change in the musculoskeletal system, it is increasingly seen as being associated with declining neurological function and brain health. Grip strength and muscle coordination, which are included in the maximum handgrip strength assessment, are largely controlled by the nervous system. Therefore, handgrip strength can be a potential indicator of nervous system function and may reflect brain health. However, the difference in handgrip strength between the hands, referred to as handgrip strength asymmetry, has recently been proposed as a potential indicator of decreased cognitive function.[12] A large motor asymmetry in functional performance between the hands may indicate a deficit in nervous system function or an imbalance in cerebral hemisphere activation.[13] Therefore, handgrip strength asymmetry can be assessed using data obtained during standard handgrip strength assessments. The aim of this study was to determine the relationship between physical activity level, handgrip strength, handgrip asymmetry, and nutritional status in geriatric individuals with and without diagnosed neurodegenerative diseases.

Methods

This research was conducted in a nursing home in Istanbul between November 2023 and March 2024. Ethical approval was received from the Marmara University Faculty of Health Sciences Non-Interventional Clinical Research Ethics Committee (28.12.2023/150). The participants were informed about the research, and their written consent was obtained. The research was conducted following the principles stated in the Helsinki Declaration.

Participants and Sample Size

Geriatric individuals over the age of 65 years who were diagnosed with neurodegenerative diseases, such as Alzheimer's and dementia (study group) and geriatric individuals in a similar age group who were not diagnosed with neurodegenerative diseases (control group) were included in the study. Geriatric individuals who were amputees, severely demented, immobile and/or had malignant tumors were excluded from the study. The sample size was calculated with the Clincal Program. When the power was set as 80% and alpha as 0.05, it was calculated that there should be a minimum of 18 people in the study and control groups, and due to the losses that may occur during the research process, 27 people were included in each group, and a total of 54 participants were recruited.

Data Collection Tools

A face-to-face survey was conducted on individuals who volunteered to participate in the study. Sociodemographic characteristics, such as age, gender, and educational status were questioned in the survey. Height (cm), body weight (kg), mid-upper arm circumference (MUAC) (cm) and calf circumference (cm) measurements were taken from the participants in accordance with previously described measurement procedures.[14]

In this study, a hydraulic digital hand dynamometer (Charder MG4800 Medical Hand Grip Dynamometer, Charder Electronic, Taiwan) was used to measure HGS. The Hand Grip Strength Test was applied as described by Vaishya et al. (2024).[10] The test position was sitting on a backed chair on a flat surface, arms adjacent to the body and relaxed, elbow flexed 90 degrees, wrist 0-30 degrees open and 0-15 degrees ulnar deviation. For grip strength measurement, the dynamometer was held in an upright position. The participant was asked to squeeze the dynamometer as hard as possible with their dominant hand for five seconds while in the appropriate position. The preferred method for a trial where the maximum measurement will be obtained is to find the average of three measurements.[10] When maximum power is measured many times in a short time, individual fatigue creates a problem and can give erroneous results. Participants rested for 60 seconds between trials.[15]

The strength difference measurement was used to assess the asymmetry of HGS. The difference between the measurements for the right and left hand was calculated and a percentage of this difference was used to determine the degree of asymmetry. The percentage HGS difference between the hands was calculated as follows: the ratio of maximal non-dominant HGS and maximal dominant HGS was calculated (non-dominant HGS/dominant HGS). The "10% rule" was applied to define HGS asymmetry as the overall 10% difference in HGS between the dominant and non-dominant hands. Participants with a ratio of less than 0.9 or greater than 1.1 were classified as having HGS asymmetry.[16]

The physical activity levels of participants were assessed by using the Turkish version of the International Physical Activity Questionnaire Short Form (IPAQ) which was validated by Saglam et al (2010).[17] The questions in the survey ask how many days and how much time the person did vigorous physical activity, moderate physical activity, and walking in the last seven days. In addition, the daily sedentary (sitting, lying) time is also determined.

The physical activity level is indicated by the metabolic equivalent (MET). Vigorous physical activity corresponds to a physical activity level of 8.0 METs, moderate physical activity to 4.0 METs, walking to 3.3 METs, and sitting to 1.5 METs. In the calculation, the MET values in the relevant activity group are multiplied by the minutes and days spent. The MET value of the activity performed in a week is calculated. The MET value of vigorous physical activity, the MET value of moderate physical activity, and the MET value of walking are added together to determine the total physical activity value in a week. According to the determined MET value, the physical activity levels of the participants are categorized as "Inactive Level" (599 METs and below), "Minimal Active Level" (between 600 METs and 3000 METs) and "Sufficiently Active Level" (above 3000 METs).[18]

Mini Nutritional Assessment (MNA) screening tool was applied to determine the malnutrition status of the participants. MNA categorizes the nutritional status of individuals as normal (adequate nutritional status), borderline (at risk of malnutrition) and malnutrition (protein-energy malnutrition). Individuals can receive a maximum of 30 points from MNA. A score less than 17 indicates malnourished and between 17 and 23.5 indicates at risk of malnutrition, with 23.5 or higher indicating normal nutritional status.[19]

Statistical Analysis

Data analysis was performed using SPSS, version 29.0 (IBM Inc., Armonk, NY, USA). Descriptive statistics are presented as mean±standard deviation (SD) or median and interquartile range (IQR) for continuous variables, as appropriate, and frequencies and percentages for categorical variables. The normality of the distribution was analyzed using the one-sample Kolmogorov–Smirnov test. Chi-square test was used to compare categorical data. Mann-Whitney U and Independent Sample t-test were used for continuous and two-group comparisons. Multiple chi-square tests were employed to assess associations between categorical variables across the study and control groups. For significant results, Cramér's V was calculated to measure the strength of association, with cut-off values interpreted as follows: 0.1 indicates a weak association, 0.3 a moderate association, and 0.5 or higher a strong association.[20] A significance level of $p<0.05$ was used.

Results

The general characteristics of the participants was shown in Table 1. No significant difference was found between individuals with and without neurodegenerative diseases in terms of age and gender distribution, education status, tobacco and alcohol use, presence of chronic disease, use of cane or walker, and applying a special diet ($p>0.05$) (Table 1).

Table 1. Characteristics of groups

	Study Group		Control Group		
	Mean	**SD**	**Mean**	**SD**	***p***
Age	76.7	7.3	74.3	7.5	0.243§
	n	**%**	**n**	**%**	
Gender					
Male	11	40.7	14	51.9	0.413†
Female	16	59.3	13	48.1	
Education Status					
Not literate	9	33.3	5	18.5	
Primary-school	14	51.9	16	59.3	0.584†
High-school	2	7.4	4	14.8	
University	2	7.4	2	7.4	
Use of Tobacco					
Yes	7	25.9	11	40.7	0.248†
No	20	74.1	16	59.3	
Alcohol Consumption					
Yes	0	0.0	1	3.7	0.313†
No	27	100.0	26	96.3	
Presence of Chronic Disease					
Yes	20	74.1	20	74.1	1.000†
No	7	25.9	7	25.9	
Use of Cane					
Yes	6	22.2	4	14.8	0.484†
No	21	77.8	23	85.2	
Use of Walker					
Yes	5	18.5	1	3.7	0.083†
No	22	81.5	26	96.3	
Specific Diets					
Yes	3	11.1	8	29.6	0.091†
No	24	88.9	19	70.4	

§ Independent Sample t-test
†Chi-square test

As shown in Table 2, the majority of the study group (59.3%) had a risk of malnutrition, while the majority of the control group (66.7%) had a normal nutritional status (p=0.031). According to the IPAQ category, the percentage of inactive participants in the study group was 40.7%, while in the control group it was 11.1% (p=0.028). A significant difference was found between the groups in terms of HGS asymmetry (p=0.003). While 74.1% of the study group exhibited HGS asymmetry, 66.7% of the control group had no asymmetry. Mean values of the right and the left HGS were found to be lower in the study group (13.3±6.4; 12.4±6.3, respectively) than in the control group (22.1±7.6; 21.0±7.2, respectively) (p<0.001). There were also significant differences between the groups in terms of HGS ratio. The mean HGS ratio in the study group (0.8±0.2) was found to be lower than in the control group (0.9±0.1) (p=0.030). No significant difference was found between the groups in terms of anthropometric measurements (p>0.05) (Table 2).

Table 2. Health related parameters of groups

	Study Group		Control Group		
	n	**%**	**n**	**%**	***p***
MNA					
Normal nutritional status	9	33.3	18	66.7	
Risk of malnutrition	16	59.3	9	33.3	0.031†
Malnourished	2	7.4	0	0.0	
IPAQ category					0.028†
Inactive	11	40.7	3	11.1	
Minimally Active	16	59.3	24	88.9	
HGS Asymmetry					
Yes	20	74.1	9	33.3	0.003†
No	7	25.9	18	66.7	
HGS Values	**Mean**	**SD**	**Mean**	**SD**	
HGS-right	13.3	6.4	22.1	7.6	<0.001§
HGS-left	12.4	6.3	21.0	7.2	<0.001§
HGS-ratio	0.8	0.2	0.9	0.1	0.030§
Anthropometric Measurements					
Body Weight (kg)	68.3	13.5	73.6	15.3	0.178§
Height (cm)	154.8	10.8	156.0	9.2	0.657§
BMI (kg/m²)	28.6	5.4	30.2	5.2	0.274§
MUAC (cm)	27.9	4.0	28.4	4.1	0.593§
Calf Circumference (cm)	33.8	4.0	35.8	3.6	0.068§

BMI: Body Mass Index, HGS: Handgrip Strength, MNA: Mini Nutritional Assessment, MUAC: Mid-Upper Arm Circumference
†Chi-Square Test
§Independent Sample t-test

The relationship between neurodegenerative disease and asymmetry according to IPAQ category is given in Table 3. According to IPAQ category, none of the participants were active. There was no statistically significant relationship between neurodegenerative disease and asymmetry in those in the inactive category (p=0.707). A strong relationship was found between neurodegenerative disease and asymmetry in participants who were minimally active (p<0.001; Cramer's V=0.572). While the majority of those with neurodegenerative disease (87.5%) had HGS asymmetry, the majority of those without the disease (70.8%) did not have HGS asymmetry. (Table 3). The Mann-Whitney U test was applied for the difference between neurodegenerative disease and right HGS, left HGS and HGS ratio according to IPAQ category and is presented in Figure 1. A significant difference was found in those in the minimally active category (p<0.001). The HGS-right median value was found to be lower in those with neurodegenerative disease at 11.6 (9.2-16.9) than in those without with a median of 24.2 (18.4-29.3) (p<0.001). The HGS-left median value was also lower in participants with neurodegenerative disease (11.4 (8.5-14.3) versus 20.8 (17.3-28.1); p<0.001). The median HGS ratio value was significantly lower in those with neurodegenerative disease (0.8 (0.7-0.8) versus 1.0 (0.9-1.0); p<0.001) (Figure 1).

Table 3. Association between groups and HGS asymmetry according to IPAQ category

IPAQ Category	**Study group HGS Asymmetry**		**Control group HGS Asymmetry**		***p***	**Cramer's V**
	Yes	**No**	**Yes**	**No**		
Inactive	6 (54.5)	5 (45.5)	2 (66.7)	1 (33.3)	0.707	0.101
Minimally Active	14 (87.5)	2 (12.5)	7 (29.2)	17 (70.8)	<0.001	0.572

Multiple Chi-Square Test

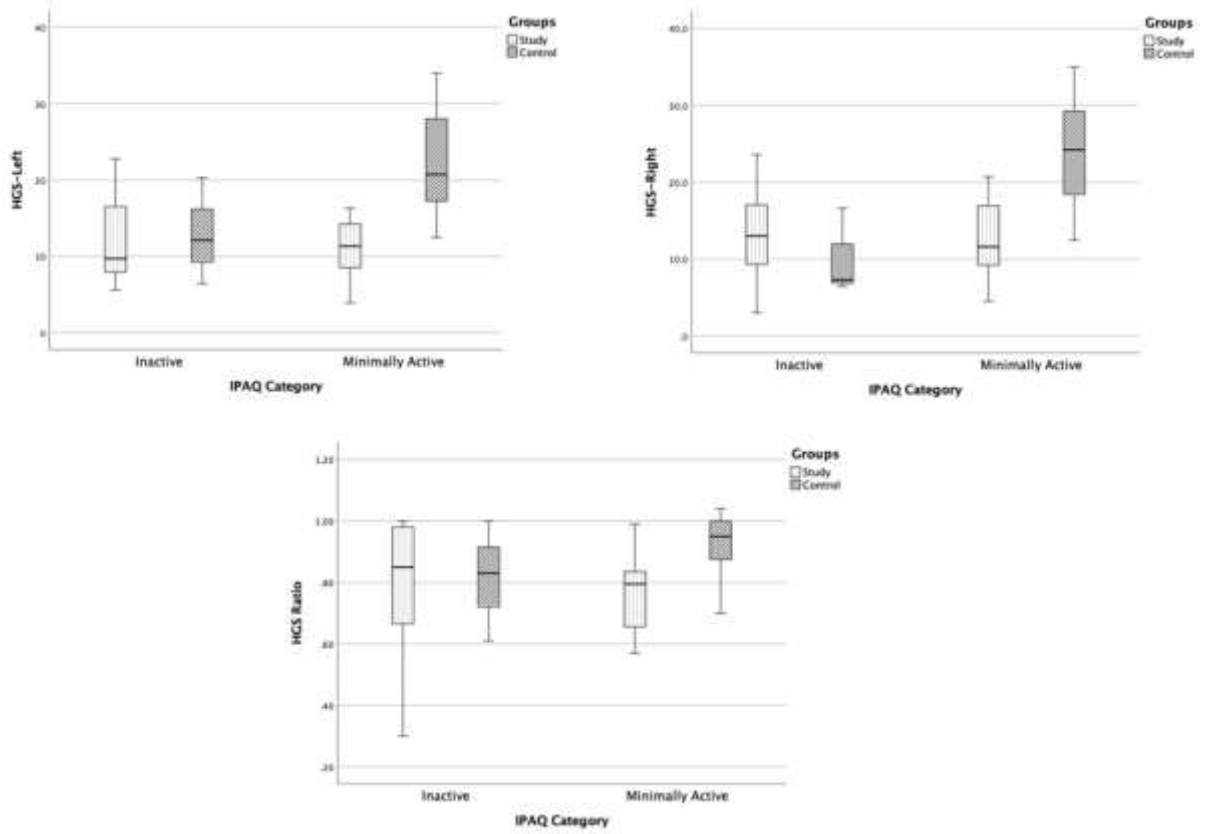

Figure 1. Difference between groups and HGS values according to IPAQ category

Discussion

This case control study highlighted that in the study group, most participants were at risk of malnutrition, while the control group exhibited normal nutritional status. Hand grip strength asymmetry was more prevalent in the study group, with lower right and left HGS values and ratios compared to the control group. No significant differences were found in anthropometric measurements between groups. Among inactive participants, there was no significant relationship between neurodegenerative disease and HGS asymmetry. However, in minimally active participants, those with neurodegenerative diseases showed greater HGS asymmetry and lower hand grip strength than those without the disease.

Reduced HGS is a reliable indicator of impaired muscle function and declining health.[11,13] It is primarily seen as a musculoskeletal change with age but is also linked to neurological function and brain health, as grip strength and muscle coordination are controlled by the nervous system.[16] HGS asymmetry has emerged as a potential marker for reduced cognitive function and functional disability.[12] Previous studies showed that HGS asymmetry and low HGS are associated with increased risk of neurodegenerative disorders and cognitive function.[12,13,16,21] Our results are in keeping with previous research, showing that individuals with neurodegenerative diseases had higher HGS asymmetry and lower overall grip strength compared to healthy controls. This supports the hypothesis that HGS asymmetry is closely linked to neurological function and cognitive health.

Neurological diseases often lead to complications, such as appetite loss, difficulty in swallowing, and motor function impairments, all of which can restrict food intake and increase the risk of malnutrition.[22] Our results confirm that individuals with neurodegenerative diseases have poorer nutritional status compared to those without such conditions, as indicated by lower MNA scores. The higher risk of malnutrition among these patients underscores the significant impact neurological diseases have on nutrition and overall health. Muscle strength, particularly hand grip strength, is an important marker of nutritional status and is affected early in the malnutrition process. As malnutrition progresses, muscle function declines, making HGS a valuable tool in assessing and diagnosing malnutrition risks, especially in older adults.[23] In the present study, although no significant differences in anthropometric measurements were found between the groups, those with neurodegenerative diseases had lower HGS values and higher malnutrition risk, reinforcing the importance of using multiple methods, including HGS, for nutritional assessment. Previous studies have found that individuals with dementia have lower body weight and body fat percentage, as well as lower body mass index (BMI), MUAC, calf circumference, and skinfold thickness compared to those without dementia.[9,24] However, in contrast to these findings, our study did not reveal significant differences in anthropometric measurements between the groups. This highlight has shown that handgrip strength assessment is important in addition to anthropometric measurements in determining nutritional status, especially in the neurological and geriatric population.

The relationship between HGS, physical activity and neurodegenerative diseases is complex and multifaceted. Individuals with cognitive impairment may engage in less physical activity, leading to lower grip strength and reduced muscle mass and strength.[25] This decrease in physical activity is often associated with neurodegenerative diseases, where cognitive impairment may contribute to a decline in overall physical health.[21] A study examining whether HGS was associated with cognitive function in an exercise intervention found that HGS was strongly associated with cognitive function before and after a 12-week resistance exercise

intervention.[26] In the present study, HGS asymmetry was found to be higher in the minimally active group with neurodegenerative diseases compared to the control group. This suggests that neurodegenerative diseases may exacerbate muscle weakness or imbalance, especially when physical activity is limited. No significant association was found for the inactive group, suggesting that lack of physical activity may mask the effect of neurodegenerative conditions on HGS asymmetry.

The study's limitations include a small sample size, with only 27 participants per group, potentially reducing the statistical power required to generalize findings to a broader population. In addition, the study's single-site design, conducted exclusively in one nursing home, restricts the applicability of results to other regions or settings. Furthermore, its cross-sectional design limits the ability to draw causal inferences between neurodegenerative diseases, HGS asymmetry, and malnutrition, highlighting the need for further longitudinal research to assess these relationships more definitively. However, the strengths of this study lie in its multifactorial approach, utilizing diverse assessments including anthropometric measurements, objective HGS, and validated tools, including the MNA and IPAQ, which together provide a holistic view of participants' health. Moreover, by focusing on HGS asymmetry, the study contributes valuable insights into the relationship between muscle function and neurodegenerative diseases, potentially aiding early diagnosis and intervention. Furthermore, comparing HGS asymmetry across physical activity levels underscores the benefits of promoting physical activity, even for those with neurodegenerative conditions.

Conclusion

The interplay between cognitive decline, reduced physical activity, and muscle strength loss creates a cycle of worsening physical and cognitive health in neurodegenerative diseases, making HGS a valuable measure for assessing both neurological and physical function in geriatric populations. Findings from this study support broader incorporation of assessment of HGS asymmetry in neurological evaluations, underscoring the need for further research to validate its clinical relevance. Comprehensive assessments incorporating HGS, nutritional status, and physical activity may play a crucial role in early detection and management of neurodegenerative conditions among older adults. Future studies with larger sample sizes and longitudinal follow-up could enhance these insights and contribute to effective intervention strategies.

Conflict of Interest

There are no disclosed conflicts of interest for the authors.

Compliance with Ethical Statement

The research was approved by the Marmara University Faculty of Health Sciences Non-Interventional Clinical Research Ethics Committee (28.12.2023/150). Participants were informed about the research and their written consent was obtained.

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Author's Contributions

G.S., A.H.İ., Ş.B., İ.M., S.N.T, Ş.A. Study idea/Hypothesis; G.S., A.H.İ., Ş.A. Design; Ş.B., İ.M., S.N.T. Data Collection; G.S., A.H.İ. Analysis; G.S., A.H.İ., Ş.B., İ.M., S.N.T, Ş.A. Literature review; G.S., A.H.İ., Ş.B., İ.M., S.N.T, Ş.A. Writing; G.S., A.H.İ., Ş.A. Critical review; G.S., Ş.B., İ.M., S.N.T, Funding.

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