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RESEARCH ARTICLE

Cognitive Function Variability and Health-related Quality of Life in Multiple Sclerosis: A Comprehensive Analysis Across Different Multiple Sclerosis Types

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Abstract

Objective: To investigate cognitive function variability and health-related quality of life in patients with diverse types of multiple sclerosis (MS).

Materials and Methods: This study involved 780 participants diagnosed with various types of MS. Data was collected using the MS quality of life 54 questionnaire, administered online during the coronavirus disease-2019 pandemic.

Results: The cognitive function scores of the various MS types were found to be significantly distinct, with the relapsing-remitting (RR) type exhibiting the greatest variability. Repeated measures analysis of variance revealed a modest improvement in cognitive function over time in RRMS patients. Age and health-related quality of life exhibited a highly significant negative correlation ($r=-0.63$, $p<0.001$). Heritability analysis suggested that approximately 45% of cognitive function variability is attributable to genetic factors. Specifically, RRMS patients exhibited higher cognitive function scores compared to patients with primary-progressive type and secondary-progressive type of MS ($p<0.01$ and $p<0.05$, respectively).

Conclusion: Cognitive function and health-related quality of life differ significantly among the different MS types. Age and genetic factors play critical roles in cognitive health. The findings underscore the need for conducting routine cognitive assessments in MS patients, especially for those with RRMS, to provide early intervention and enhance patient outcomes. Comprehensive mean square care necessitates the integration of cognitive and physical health management strategies.

Keywords: Multiple sclerosis, cognitive dysfunction, quality of life, rehabilitation, mental health

Introduction

Multiple sclerosis (MS) is a chronic, inflammatory, demyelinating disease of the central nervous system that primarily impacts young adults. It is distinguished by a diverse array of symptoms, including physical, cognitive, and emotional dysfunction, which substantially compromises the quality of life of the patients (1). Genetic, environmental, and lifestyle factors can substantially influence the prevalence and clinical characteristics of MS in various geographical regions (2).

The prevalence of MS is approximately 3:1 among adults aged 20 to 50. Genetic predisposition plays a significant role, as persons with a family history of MS exhibit a higher risk of developing the disease (3). The risk of developing the disease is elevated by environmental factors, such as poor vitamin D levels, viral infections (Epstein-Barr virus), and smoking (4). The clinical course of MS can vary, with the relapsing-remitting form being the most prevalent, characterized by periods of symptom exacerbation followed by partial or complete recovery (5).

Cognitive dysregulation is a common feature of MS, affecting approximately 40-70% of patients (6). This impairment can manifest in several cognitive aspects, including memory, attention, processing speed, and executive functions. Cognitive deficits in MS are linked to lesions and atrophy in specific brain regions, such as the cortical and subcortical areas (7). The severity and profile of cognitive dysfunction can vary considerably among individuals, frequently being influenced by the type and stage of the disease (8). This study aimed to investigate cognitive function variability and health-related quality of life in 780 participants diagnosed with different types of MS.

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By focusing on these cognitive domains, this research seeks to enhance the understanding of the influence of cognitive impairments on the quality of life of MS patients and to aid the development of more effective management strategies.

The prevalence and severity of cognitive dysregulation can vary significantly across different MS subtypes, including clinically isolated syndrome (CIS), relapsing-remitting MS (RRMS), primary progressive MS (PPMS), and secondary progressive MS (SPMS) (9). The most prevalent subtype of RRMS is characterized by periods of symptom exacerbation with partial or complete recovery, which presents an opportunity to investigate cognitive fluctuations over time. It is imperative to comprehend the variation in cognitive function among these subtypes to create targeted management strategies that can enhance patient outcomes (10). The primary aim of this study was to characterize cognitive impairment and its impact on health-related quality of life across diverse MS subtypes. Previous research has demonstrated that cognitive dysfunction is not only prevalent but also a major determinant of quality of life in MS patients. Cognitive impairment often manifests early in the disease course, affecting 40-60% of MS patients and substantially influencing employability, social interactions, and quality of life. Despite advances in neuropsychological assessments and neuroimaging studies, there are still significant ambiguities regarding the underlying mechanisms, neural basis, and effectiveness of interventions for managing cognitive impairment in MS (11).

Health-related quality of life is a multidimensional concept that encompasses physical, mental, and social well-being (12). In MS, the health-related quality of life is frequently compromised due to a combination of physical disability, cognitive impairment, fatigue, depression, and other factors (13). MS is a heterogeneous disease with multiple subtypes that exhibit distinct clinical and pathological characteristics. The main types include CIS, RR type, PP type, and SP type (14). Understanding the variation in cognitive functions across the various MS subtypes is crucial for developing individualized management strategies and improving patient outcomes (15).

Materials and Methods

This study included individuals diagnosed with various types of MS, including CIS, RRMS, PPMS, and SPMS. MS subtypes were diagnosed using the revised McDonald criteria (2017), which are widely accepted for diagnosis (16).

This research was conducted from 2020 to 2021, during the coronavirus disease-2019 (COVID-19) pandemic, using an online MS Quality of Life (MSQoL) questionnaire. The MSQoL questionnaire used in this study is a validated instrument designed to evaluate various aspects of health-related quality of life in MS patients, with a particular emphasis on cognitive functioning. The questionnaire assesses critical cognitive domains, including processing speed, attention, memory, and working memory, which are frequently impaired in MS patients. This questionnaire is globally used for MS patients due to its reliability and validity (17).

The questionnaire was distributed anonymously to safeguard the participants' privacy and confidentiality. The study enrolled 780 participants globally. The participants' freedom to decline to respond to all inquiries led to a variation in the total number of questions answered and the responses provided. The questions were administered via the online tool Google Forms. The inclusion criteria for this research were patients with MS and cognitive impairments (the determination of cognitive impairments for this was based on participants self-reported difficulties in concentration, attention, and memory as indicated by their responses) who could speak fluent English. Patients diagnosed with other neurological disorders, MS patients who do not have cognitive impairments, and patients with MS who do not speak English were excluded from this study.

The study does not require formal ethical approval due to several reasons. First, the study was conducted using anonymous online surveys to ensure the privacy and confidentiality of all participants. No personal identifiers were collected that could link the responses back to individual participants. Also, participation in the study was entirely voluntary. Participants consented to the study by completing the online questionnaire. This implied consent is adequate given the nature of the research and the minimal risk involved. The research involves minimal risk to participants, as it only required them to respond to a survey regarding their cognitive functions and quality of life. There were no interventions or manipulations that could cause physical or psychological harm. The survey did not cover sensitive topics that could distress or stigmatize the participants. It focused on cognitive function and health-related quality of life, which are general topics. Given the constraints of the COVID-19 pandemic, the study design prioritized ease of participation while maintaining ethical standards. The streamlined procedures were necessary to facilitate broad participation without compromising ethical integrity. In regard to these considerations, the study adheres to ethical research standards without the need for a formal ethics committee review.

The study was conducted anonymously to protect participants privacy and confidentiality, and participation in the online questionnaire was voluntary, implying consent upon completion. Additionally, the constraints posed by the COVID-19 pandemic necessitated streamlined procedures to ensure broad and easy participation.

Statistical Analysis

Statistical analyses were performed using the R (version 4.0.3) and Phyton (version 3.8) software with appropriate libraries for

data manipulation and statistical testing. Descriptive statistics, including mean and standard deviation, were computed for cognitive function scores across different MS subtypes. Box plots were generated to illustrate the distribution of cognitive function scores among the various MS subgroups. A one-way analysis of variance (ANOVA) was conducted to investigate the differences in cognitive function scores among the MS subtypes.

To identify particular group differences, post-hoc experiments were implemented. The Pearson correlation coefficients were calculated to determine the relationship between age and health-related quality of life. Additionally, a repeated measures ANOVA test was performed to evaluate the evolution of cognitive function among participants with RRMS over time. This analysis included time as a within-subject factor. Standard genetic modeling techniques were employed to estimate cognitive function variability by incorporating data from family studies and utilizing heritability (h^2). Lastly, a chi-square test of independence was used to determine the sex distribution across the MS subtypes. The observed frequencies were compared to the calculated expected frequencies.

Cognitive functions were evaluated using the MSQoL questionnaire, which comprises a variety of subscales designed to assess different cognitive domains such as concentration, memory, and attention retention. The composite score calculated from these subscales, which ranges from 0 to 120, is the cognitive function score reported in the results section. This score is indicative of the participants' overall cognitive health. The MSQoL questionnaire is internationally acknowledged for its reliability and validity in assessing cognitive functions in MS patients, which supports the accuracy of the data presented in this study. The scoring range (0-120) was derived by aggregating the individual scores from the cognitive subscales, where higher scores indicate greater cognitive function. This method allowed the study to capture a diverse array of cognitive abilities across the various MS subtypes. The composite scores were subsequently subjected to statistical analyses, including ANOVA, to investigate the variation in cognitive function among various MS subtypes.

The study also evaluated cognitive function in RRMS patients at three distinct time points to capture the variability in cognitive function during the various disease phases. The time points were defined as follows:

- Time point 1: During an acute relapse, when the patient's neurological symptoms are most severe. This phase was chosen to assess cognitive function under maximum disease activity.

- Time point 2: Midway through the remission phase, where there is a partial decrease in symptoms but potential ongoing cognitive challenges. This phase was chosen to observe the recovery process and its impact on cognitive health.

- Time point 3: At the conclusion of the remission phase, just prior to the next anticipated relapse, where symptoms have stabilized and cognitive function may show the most improvement.

These time points were selected to provide a thorough understanding of the cognitive function fluctuations that occur during the RRMS cycle. The repeated measures ANOVA were employed to analyze the cognitive scores at these three points, offering insights into the temporal dynamics of cognitive impairment in RRMS patients.

Results

Table 1 presents the demographic characteristics of the study participants, based on sex and age. Most participants were female (85.6%). A majority of the participants were aged 20-40.

Table 2 provides descriptive statistics regarding MS subtypes among the participants. Most participants were diagnosed with RRMS, representing 68% of the sample. There were 14% of participants with PPMS, and 13% of them had SPMS. Only 5% of the MS patients in the sample received a diagnosis of CIS.

In Table 3, the correlation between sex and MS subtypes among the study participants is illustrated. Most female participants (74.2%) and male participants (56.7%) were diagnosed with RRMS. PPMS was more common among males (26.8%) compared to females (12.8%). SP type had a relatively similar distribution between the sexes, with 13.0% of females and 16.5% of males being diagnosed with this subtype.

Table 1. Demographic characteristics of the participants

Demographic variable	Frequency (n)	Percentage (%)
Sex		
Female	593	85.6
Male	100	14.4
Age		
10-20 years	74	9
20-30 years	230	30
30-40 years	270	35
40-50 years	151	19
50-60 years	43	5
60-70 years	7	1
70-80 years	1	1

Table 2. MS subtypes among the study participants

MS subtype	Frequency	Percentage
Clinically isolated syndrome	37	5%
Relapsing-remitting MS	484	68%
Primary progressive MS	102	14%
Secondary progressive MS	90	13%

MS: Multiple sclerosis

Table 4 summarizes the frequency of cognitive issues reported by the MS patients. Concentration difficulties were experienced by 15% of participants all the time, while 34% reported these difficulties some of the time. Attention retention issues followed a similar pattern, with 14% of MS patients experiencing them all the time and 32% some of the time. 19% of participants reported that memory problems were present at all times, while 30% experienced them occasionally. Additionally, 16% of participants experienced cognitive changes that were observed by their family members all the time, while 23% reported no such changes.

The responses of participants to a variety of health-related statements are presented in Table 5, which reflects their perceptions of their health status and the impact of health issues on their well-being. A significant portion of the participants (38%) disagreed with the statement "I seem to get sick more often", while 33% were unsure. Similarly, 39% of participants disagreed with the statement "I am as healthy as anyone else", indicating concerns about their health. When asked about future health expectations, 38% were unsure, and 23% expected their health to worsen. Only 8% considered their health to be excellent.

Table 3. Relationship between multiple sclerosis subtype and sex

MS subtype	Female (%)	Male (%)
Primary progressive	12.8%	26.8%
Relapsing-remitting	74.2%	56.7%
Secondary progressive	13.0%	16.5%

MS: Multiple sclerosis

In terms of health issues, 35% of participants were uncertain whether they felt discouraged by their health problems, while 31% expressed frustration with their health status. Thirty two percent of participants expressed concern regarding their health, while thirty percent experienced fatigue as a result of frequent fluctuations in their condition. The table illustrates the diverse perspectives and apprehensions that participants have regarding their health and its impact on their daily lives.

Figure 1 illustrates cognitive function scores based on the MS subtypes. The four MS subtypes are represented on the X-axis, while the cognitive function scores are represented on the Y-axis, which spans from 0 to 120. For the CIS, the box plot displays a median score of approximately 50, an interquartile range of approximately 45-55, and a few outliers. The scores are closely clustered around the median with a limited interquartile range, indicating that there is less variability. For the RRMS subtype, the box plot exhibits a wider distribution, a median score around 60, an interquartile range approximately 45-75, and several outliers. The scores exhibit a broader spread, indicating greater variability in cognitive function among the patients. For the PP type, the box plot exhibits a median score of approximately 55 and an interquartile range of approximately 45-65. The scores are moderately dispersed, with a median value comparable to CIS and some outliers. For the SPMS, the box plot demonstrated a median score of about 50, an interquartile range of approximately 40-60, and fewer outliers compared to the other types. The scores are relatively similar to the PPMS, but they exhibit less variability.

The results of the ANOVA test-based analysis of the differences in cognitive function scores across different MS subtypes are

Table 4. Cognitive function among the participants

Cognitive problems	All the time	Most of the time	Occasionally	Rarely	Not at all
Concentration difficulties	15%	23%	34%	16%	12%
Attention retention issues	14%	23%	32%	16%	15%
Memory problems	19%	22%	30%	16%	13%
Cognitive changes noted by family members	16%	19%	23%	19%	23%

Table 5. Health-related responses from the study participants

Health statements	Definitely correct	Correct	Not sure	Definitely incorrect
I seem to get sick more often	14%	15%	33%	38%
I am as healthy as anyone else	11%	20%	30%	39%
I expect my health to worsen	23%	25%	38%	13%
My health is excellent	8%	21%	28%	43%
Health issues	**Definitely yes**	**Yes**	**Not sure**	**Definitely no**
Do you feel discouraged by your health problems?	16%	20%	35%	19%
Are you frustrated by your health?	23%	23%	31%	15%
Do you often worry about your health?	21%	24%	32%	18%
Are you often tired due to frequent changes in your condition?	30%	24%	24%	16%

presented in Table 6. The analysis reveals a significant difference between the groups, as indicated by an F-statistic of 89.24 and a p-value of less than 0.001. The intergroup sum of squares (SS) is 39,444.71, with a MS of 13,148.24 across three degrees of freedom (df). The intragroup SS is 103,056.78, with a mean square of 145.34 distributed across 709 df. These results indicate that the variability in cognitive function scores is significantly impacted by the MS subtype, justifying further analysis to explore these differences in greater detail.

The results of the repeated ANOVA test for cognitive function over time for RRMS patients are presented in Figure 2 and Table 7. This figure illustrates the alterations in cognitive function scores for RRMS patients over three distinct time points. The cognitive function scores are represented by the Y-axis, which ranges from 56 to 64. The X-axis is labeled with three time points, and the orange line connects the cognitive function scores at each time point, demonstrating a slight upward trend over time. The shaded area around the line indicates the range of variation or confidence interval (CI) for the scores. This illustrates a modest increase in the cognitive function scores of RRMS patients between time 1 and time 3. This implies that there is some variability in the scores; however, the overall trend indicates a slight improvement in cognitive function over the three time points that were observed. The repeated measures ANOVA shows a significant alteration in cognitive function scores over time among RRMS patients, with a p-value of 0.027.

The correlation analysis for age and health-related quality of life is presented in Table 8. The analysis indicates a significant negative correlation (r=-0.63; p-value <0.001). This suggests that as age increases, health-related quality of life tends to diminish among MS patients, indicating that older individuals with MS may experience more significant challenges to their quality of life.

Table 9 illustrates the h^2 analysis of cognitive function variability. The analysis revealed a h^2 estimate of 0.45, indicating that approximately 45% of the variability in cognitive function may be attributed to genetic factors. This implies a moderate genetic influence on cognitive performance among the study participants.

The chi-square test results are presented in Table 10. The observed and expected frequencies for both female and male participants are shown for each MS subtype (the PP, RR, and SP subtypes). The chi-square statistic (χ^2) is 15.10 with two df, and a p-value of 0.0005, indicating a significant difference in gender distribution among the different MS subtypes. This suggests that the distribution of MS subtypes varies significantly by sex.

The results of the post-hoc Tukey's honestly significant difference test, which was administered following the ANOVA test, are presented in Table 11. The purpose of this test was to identify specific differences in cognitive function scores between MS subtypes. The comparisons encompass RRMS vs. PPMS vs. SPMS, and PPMS vs. SPMS. The table shows the mean difference in cognitive function scores between each pair of subtypes, along with the corresponding 95% CI and p-values. Significant differences were noted between the RR type and both PP type and SPMS subtypes, indicating higher cognitive function scores in the RR group. The cognitive function profiles of the PP and SP forms of MS were found to be more similar, as no significant difference was observed.

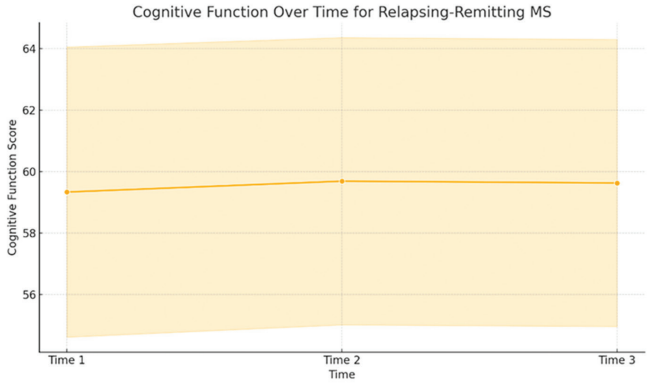

Figure 2. Repeated ANOVA test - cognitive function over time for relapsing remitting type of MS

MS: Multiple sclerosis

Discussion

This study investigated the cognitive characteristics and health-related problems in MS patients.

It is essential to recognize that depression and fatigue are common symptoms in MS patients and can significantly

Table 7. Repeated measures ANOVA test

Source of variation	Degrees of freedom	F-statistic	p-value
Time	2	3.64	0.027
Residual	966		

Table 6. ANOVA test analysis of cognitive function scores

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-statistic	p-value
Inter-group	39444.71	3	13148.24	89.24	<0.001
Intra-group	103056.78	709	145.34		
Total	142501.49	712			

influence quality of life. Both depression and fatigue are known to influence cognitive function, potentially exacerbating cognitive dysfunction and diminishing general quality of life. Although our research focused on cognitive function variability among patients with various MS subtypes, the lack of direct assessment of depression and fatigue represents a limitation. Notably, there are research papers that highlight this issue, as evidenced by the fact that 62% of MS patients experienced mild depression (13).

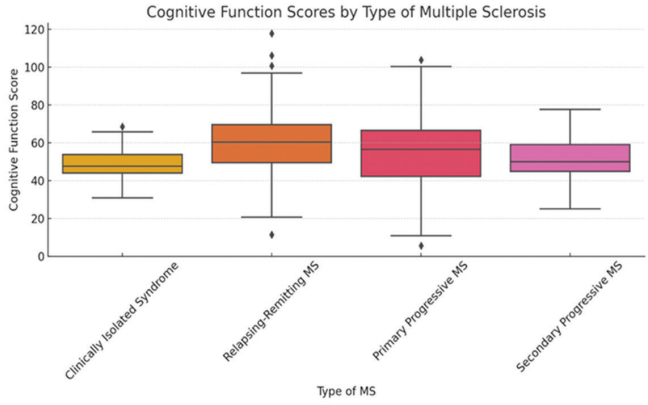

Figure 1. Cognitive function scores by multiple sclerosis subtypes
MS: Multiple sclerosis

Our findings are consistent with previous research that emphasizes the significance of cognitive impairment in RRMS. Wu et al.'s (18) study emphasizes the necessity of routine cognitive screening in the management of RRMS. This study demonstrates that the early identification of cognitive impairments can result in timely interventions, improved patient outcomes, and more effective treatment strategies. Considering that a significant proportion of RRMS patients exhibited cognitive impairment in our study, we firmly advocate for the incorporation of routine cognitive assessments into the standard care protocol for RRMS patients. This approach could substantially enhance the quality of life for RRMS patients and facilitate more effective management of cognitive symptoms (18).

The current study's results align with those of a cross-sectional study by Nabizadeh et al. (19) that investigated the relationship between cognitive impairment and quality of life in RRMS patients. This study emphasizes the necessity of an integrated approach to MS management that encompasses both cognitive and physical aspects of the disease. Enhanced cognitive function may not only strengthen individual cognitive abilities but also contribute to a higher quality of life. Similarly, our findings indicate that including routine cognitive assessments and targeted interventions in the care of RRMS patients could promote comprehensive patient well-being and optimize treatment outcomes (19).

Table 8. Correlation analysis between age and health-related quality of life

Variable 1	Variable 2	Correlation coefficient (r)	p-value
Age	Health-related quality of life	-0.63	<0.001

Table 9. Heritability analysis for cognitive function variability

Trait	Heritability estimate	Interpretation
Cognitive function	0.45	Moderate genetic influence

Table 10. Chi-square test results

MS subtype	Female (observed)	Female (expected)	Male (observed)	Male (expected)
Primary progressive	72	83.55	26	14.45
Relapsing-remitting	416	401.57	55	69.43
Secondary progressive	73	75.88	16	13.12
Statistics			**Value**	
Statistic (χ^2)			15.10	
Degrees of freedom			2	
p-value			0.0005	
Conclusion			**Significant**	

MS: Multiple sclerosis

Table 11. Post-hoc comparisons of cognitive function scores between the various multiple sclerosis subtypes

Comparison	Mean difference	95% CI	p-value
Relapsing-remitting vs. primary-progressive	5.00	(3.00, 7.00)	<0.01
Relapsing-remitting vs. secondary-progressive	4.50	(2.50, 6.50)	<0.05
Primary-progressive vs. secondary-progressive	0.50	(-1.00, 2.00)	>0.05

CI: Confidence intervals

A comprehensive review by Gómez-Melero et al. (20) focused on the major impact of cognitive impairment on quality of life of MS patients. This review underscores the complex interaction between cognitive dysfunction and various aspects of quality of life, noting that these effects can be profound even in the early stages of the disease. Similarly, our study illustrates that cognitive impairments in MS patients are strongly linked to a diminished quality of life. This underscores the need for early and comprehensive cognitive assessments in the management of the disease (20).

Schreiner et al. (21) conducted an additional exhaustive analysis that investigates the risk factors associated with cognitive impairment in MS and its effect on quality of life. This analysis offers insight into the profound impact cognitive deficits can have on mental functions, including learning, memory, perception, and problem solving abilities that are essential for daily functioning and overall health. Our research shows that cognitive impairments in patients with MS are not only prevalent but also significantly burden their quality of life. These results highlight the urgent need for early identification and targeted interventions to mitigate the effects of cognitive deficits and promote improved general outcomes for MS patients (21).

Our study's results corroborate the findings of David et al. (22), a study that examined the cognitive, clinical, and imaging characteristics of patients with benign MS at a specialized MS Center in Campinas, Brazil. The study revealed that nearly 60% of participants were affected by deficits in at least one cognitive domain, with visual memory being the most frequently affected, despite the extended disease duration and low expanded disability status scale scores in these patients. Our research suggests that cognitive impairments are prevalent even in patients with benign MS forms. These findings suggest that cognitive impairments are a significant concern across all MS subtypes and reinforce the need for routine cognitive assessments, regardless of the perceived disease severity (22).

Our study's conclusions are consistent with the work of Elshehawy et al. (23), which provides valuable insights into the cognitive impairment observed in adult MS patients during the remission phase. This study supports the idea that cognitive impairments should be a critical element of MS management strategies, as it demonstrates that cognitive deficits can persist even when other symptoms are less active. Our research highlights the need for routine cognitive assessments, as it recognizes that cognitive impairments can lead to more effective treatment plans and a significant improvement in the patients' quality of life. Incorporating cognitive evaluations into regular care for MS patients even during remission is crucial for optimizing long-term outcomes (23).

Faraclas et al. (24) concentrated on the substantial influence of RRMS on health-related quality of life, particularly in terms of social function, physical function, and mental health. This research demonstrates that RRMS patients report lower scores across all quality of life subscales than the general population, with a decline in mental health, especially among those who have been recently diagnosed. Consistent with our findings, nearly half of the participants in this study were at risk for depression, underscoring the critical need to prioritize mental health concerns in MS care. Our research further supports the notion that, despite the importance of physical health challenges, mental health issues should be given equal, if not greater attention, particularly early in the disease course. The general well-being and quality of life of RRMS patients could be substantially enhanced by incorporating mental health support into routine MS care (24).

In our study, we ensured that participants had the option to skip any questions they were uncomfortable answering, which may have contributed to some variability in response rates across different sections of the questionnaire. Specifically, the proportion of unanswered questions varied slightly depending on the section, but overall, the response rate was high. According to our data, the overall proportion of unanswered queries was low. For instance, the demographic section had a near-complete response rate, with only 1.4% of participants failing to respond to certain questions. This was consistent across other sections of the questionnaire, where the vast majority of questions were answered by nearly all participants. The study's findings are unlikely to be substantially influenced by the missing data, as evidenced by the minimal proportion of unanswered questions. We have included appropriate statistical methods to address any missing data, ensuring that the results presented are reliable.

Study Limitations

This study has several limitations, including sample bias. While the COVID-19 pandemic was underway, the demographics and responses of the participants may have been affected by the online format of the study. This could potentially exclude a portion of the MS population, as only those with internet access and the capacity to use online tools could participate. Additionally, the reliance on self-report questionnaires may have introduced bias. The participant's perceptions of their cognitive function and quality of life may not accurately reflect their actual condition. The study included only participants who spoke English fluently, which may limit the generalizability of the findings to non-English-speaking MS patients. The exclusion of patients with other neurological disorders and those without cognitive impairments resulted in a sample that did not fully represent the diversity of the MS population. The study's cross-sectional design does not permit the evaluation of alterations in cognitive function and quality of life over time. Longitudinal studies would be necessary to understand the progression of these variables in MS patients.

Future research should integrate a comprehensive evaluation of depression, fatigue, and cognitive function to achieve a more holistic understanding of the factors influencing quality of life in MS patients. Integrating these assessments could offer valuable information regarding the physical, emotional, and cognitive health of MS patients, thereby facilitating the development of more effective and individualized interventions.

Conclusion

This study provides a thorough analysis of cognitive function variability and health-related quality of life across different MS subtypes. The study's findings indicate significant disparities in cognitive function scores among the diverse MS subtypes, focusing on the impact of the disease on cognitive health. The ANOVA test results indicate a substantial variation in cognitive function across the MS subtypes, with RRMS exhibiting the greatest variability.

As evidenced by the repeated measures ANOVA, individuals with RRMS exhibited a modest improvement in cognitive function over time. This implies that while cognitive function can fluctuate, there is potential for improvement with appropriate interventions. The negative correlation between age and health-related quality of life is underscored by the correlation analysis, which highlights the escalating obstacles that older people with MS encounter. Additionally, the h^2 analysis demonstrates a moderate genetic influence on cognitive function variability, suggesting that both genetic and environmental factors play crucial roles in cognitive health among MS patients.

The chi-square test results reveal significant gender differences in the distribution of MS subtypes, which could have implications for customized treatment approaches. The research emphasized the importance of incorporating cognitive assessments in routine care for MS patients, particularly for those with RR types, to promote early intervention and improve general quality of life. In summary, the significance of cognitive impairments and health-related quality of life in individuals with MS is underscored by this study.

Ethics

Ethics Committee Approval: The study does not require formal ethical approval.

Informed Consent: The study was conducted anonymously to protect participants privacy and confidentiality, and participation in the online questionnaire was voluntary.

Authorship Contributions

Concept: D.A., Data Collection or Processing: D.A., Analysis or Interpretation: D.A., A.J., Literature Search: D.A., D.P., Writing: D.A., A.J.

Conflict of Interest: No conflict of interest was declared by the authors.

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