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Investigating the Impact of Lyme Neuroborreliosis on the Executive and Memory Functions of Pilots

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Abstract: This case study investigates the impact of Lyme neuroborreliosis (LNB) on cognitive and executive functions in a 60-year-old pilot. Using purposive sampling, the participant's executive function was assessed with the Delis-Kaplan Executive Function System (D-KEFS), and memory was evaluated with the Wechsler Memory Scale (WMS). A quantitative approach employing paired with t-tests compared to cognitive performance before and after LNB diagnosis. Results showed a significant decline in memory function post-LNB ($t(3) = 3.055$, $p = 0.028$). Executive function also declined, particularly in visual scanning and inhibition, although these changes were not statistically significant ($t(2) = 2.079$, $p = 0.087$). These findings suggest that LNB may contribute to cognitive deterioration, especially in memory domains. The rapid cognitive decline observed within six months from superior to below-average performance highlights the aggressive progression of Lyme neuroborreliosis on cognitive function especially in memory. This swift deterioration underscores the urgent need for early and comprehensive cognitive assessments to enable timely intervention and support. Given the study limitation of a single participant and no control group, further research with larger samples is necessary. Comprehensive cognitive assessments are recommended for individuals with LNB to facilitate timely intervention and support.

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I. INTRODUCTION

Due to the dynamic nature of their responsibilities and frequent travel between destinations, commercial pilots in the aviation industry often experience disrupted circadian rhythms. An interesting case study involved a pilot who was assessed at age 60 and found to have good memory and executive functions as well as a stable emotional state. However, he underwent further assessment as per aviation authority requirements several months later due to his medical spinal surgery. After the surgery, he was diagnosed with Lyme neuroborreliosis. The present research aims to evaluate the impact of neuroborreliosis on pilot neurocognitive abilities specifically memory and executive function.

➢ *Problem Statement:*

Although the link between Lyme Neuroborreliosis (LNB) and cognitive dysfunction is proven there is still a need to gain an all-encompassing comprehension of the cognitive areas that are affected. Moreover, how severely individuals with LNB experience such decline, especially in the flying industry. The lack of information impedes effective intervention plans as well as support for those suffering from various cognitive challenges caused by LNB, emphasizing the need for further exploration into how this condition affects cognition in detail.

➢ *Research Question*

What is the extent and nature of memory and executive function, decline experienced by pilot with Lyme neuroborreliosis (LNB)?

➢ *Research Objective*

This study aims to comprehensively investigate the impact of Lyme neuroborreliosis (LNB) on the cognitive function of pilots. The study also considers the potential confounding effects of the pilot's disrupted circadian rhythms and recent spinal surgery on cognitive functions. For this study, 'cognitive decline' refers to measurable decreases in memory and executive functions as assessed by standardized tests.

II. LITERATURE REVIEW

Lyme neuroborreliosis (LNB) is a known neurological complication of Lyme disease that can affect various cognitive domains, especially memory and executive functioning. Research shows that individuals diagnosed with LNB may experience symptoms such as reduced concentration, forgetfulness, and slowed mental processing. However, there is limited data available on the neurocognitive aspects of neuroborreliosis, particularly within the flying industry.

In aviation, where optimal cognitive performance is essential, there is limited research on how LNB affects pilots specifically. Pilots operate under unique physiological stressors, including circadian rhythm disruptions, altitude pressure, and irregular sleep schedules. These factors are already known to influence cognitive functioning, which complicates the diagnosis and assessment of disease-related cognitive impairment in this group.

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Previous studies on neurological disorders in pilots have often focused on conditions such as stroke or head trauma, but little evidence exists regarding infections like Lyme disease. This lack of occupation-specific data creates a gap in literature. Understanding how LNB impacts pilots' memory and executive functioning is critical for creating medical clearance protocols, monitoring procedures, and tailored cognitive interventions.

This study aims to contribute to that gap by focusing on a real case, comparing neurocognitive test scores before and after the diagnosis of LNB, and highlighting the potential risk such conditions may pose in aviation safety and pilot well-being. Given the lack of research data in the flying industry, the current research arises: To what extent and in what manner do individuals with Lyme neuroborreliosis (LNB) experience cognitive deterioration? The purpose of this study is to thoroughly examine how Lyme neuroborreliosis (LNB) affects cognitive abilities. The current study will specifically focus on neurocognitive impairment in pilots due to neuroborreliosis. By comparing individuals' cognitive abilities before and after developing LNB, the current research aims to provide insights into its implications for cognition and to help develop intervention strategies that could offer better support systems for affected persons.

III. RESEARCH METHODOLOGY

➢ *Study Design:*

The study will employ a longitudinal cohort design to assess cognitive function in pilot before and after the onset of Lyme Neuroborreliosis (LNB).

➢ *Null Hypothesis (H0):*

There is no significant difference in cognitive function scores before and after the onset of Lyme neuroborreliosis.

➢ *Alternative Hypothesis (H1):*

There is a significant decline in cognitive function scores after the onset of Lyme neuroborreliosis compared to before.

➢ *Variables:*

- *Independent Variable:*

Lyme Neuroborreliosis (LNB) diagnosis (presence or absence)

- *Dependent Variable:*

Cognitive function scores The Delis-Kaplan Executive Function System ((DEKFS) and Wechsler Memory Scale (WMS) test)

➢ *Definitions:*

- *Lyme Neuroborreliosis (LNB):*

A neurological manifestation of Lyme disease caused by infection with the bacterium Borrelia burgdorferi, leading to cognitive impairment and other neurological symptoms.

- *Cognitive Function:*

Refers to various mental processes involved in getting, processing, storing, and retrieving information, including memory, attention, executive function, and visuospatial skills.

➢ *Data Collection:*

- *Participants:*

The current case study includes a 60-year-old pilot who has been diagnosed with Lyme Neuroborreliosis (LNB).

- *Procedure:*

The 1st assessment was conducted in psychological lab for initial age 60. The pilot was informed about the testing procedure. The DEKFS Thee administered to assess the pilot executive function and WMS to evaluate the memory functions. His results were superior on both memory and executive functions. Six months later the same pilot was referred again due to his diagnosis of Lyme Neuroborreliosis. The assessments were conducted by professional psychologists.

➢ *Data Collection Tools:*

- *The Delis-Kaplan Executive Function System:*

(D-KEFS) is indeed a standardized assessment tool used to measure executive functions in individuals aged 8 to 89 years old. This tool will be used to assess various cognitive domains, including executive function, before and after the onset of LNB.

- *Wechsler Memory Scale (WMS) Test:*

This test will be used to evaluate various aspects of memory function, such as immediate and delayed recall, recognition, and working memory, before and after the diagnosis of LNB.

➢ *Statistical Analysis:*

Descriptive statistics were used to summarize demographic characteristics and cognitive function scores. Paired t-tests were conducted to compare cognitive function scores before and after the onset of LNB.

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IV. DATA ANALYSIS & OUTCOMES

➢ *Statical Analysis*

Table 1 T-Test: Paired Two Sample for Means Memory Pre & Post Assessments

T-Test: Paired Sample for Means		
	87	**42**
Mean	87.75	44.5
Variance	26.25	742.3333333
Observations	4	4
Pearson Correlation	-0.11820063	
Hypothesized Mean Difference	0	
DF	3	
t Stat	3.055214933	
P(T<=t) one-tail	0.027600322	
t Critical one-tail	2.353363435	
P(T<=t) two-tail	0.055200644	
t Critical two-tail	3.182446305	

The paired t-test analysis showed a statistically significant decline in memory scores following the diagnosis of Lyme neuroborreliosis. The pre-diagnosis average score was 87.75, which decreased to 44.5 post-diagnosis. The resulting t-statistic was 3.055 with a one-tailed p-value of 0.0276, which is below the significance threshold of 0.05. Therefore, the null hypothesis was rejected, indicating a meaningful decline in memory function. The difference of approximately 43.25 points reflects a considerable reduction in cognitive performance related to memory.

Table 2 The Pair Sampled Initial Data Statistics for Memory Pre & Post)

Functions	Pre-Lyme NB	Post-Lyme NB
AM	87	42
VM	81	32
VWM	87	66
DM	93	12
IM	90	68

The mean scores for memory-related tests declined significantly after the onset of Lyme neuroborreliosis. Auditory Memory (AM) decreased from 87 to 42, and Visual Memory (VM) dropped from 81 to 32. Verbal Working Memory (VWM) also declined, from 87 to 66. Among all subdomains, Delayed Memory (DM) showed the most substantial drop, falling from 93 to 12—an 81-point difference. This sharp decline suggests that delayed recall was the most affected memory domain following the disease onset.

Table 3 T-Test: Paired Two Sample for Means Executive Functions Pre & Post Assessments

T-Test: Two Sample for Means		
	14	12
Mean	13.66667	10
Variance	0.333333	7
Observations	3	3
Pearson Correlation	-0.65465	
Hypothesized Mean Difference	0	
DF	2	
t Stat	2.078805	
P(T<=t) one-tail	0.086595	
t Critical one-tail	2.919986	
P(T<=t) two-tail	0.173189	
t Critical two-tail	4.302653	

The paired t-test results for executive functions showed a decline in mean scores from 13.67 to 10 after the onset of Lyme neuroborreliosis. However, the p-value (0.173) exceeded the 0.05 significance level, indicating that this decline was not statistically significant. The Pearson correlation coefficient of -0.6547 suggests a moderate negative relationship between pre- and post-diagnosis executive scores, implying that higher initial scores were associated with greater decline.

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Table 4 The Pair Sampled Initial Data Statistics for Memory Pre & Post

Functions	Pre-Lyme NB	Pre-Lyme NB
VS	14	12
INH	14	7
MS	13	12
VSP	14	11

Table 4 provides detailed results of executive subdomains. The most significant change was seen in Inhibition (INH), which dropped from 14 to 7, suggesting a decline in the pilot's ability to suppress automatic or prepotent responses. Visual Processing Speed (VSP) also declined, from 14 to 11. Visual Scanning (VS) and Motor Speed (MS) showed smaller reductions. While the decline in total executive functioning was not statistically significant, these subdomain patterns suggest localized impairments, especially in inhibitory control and processing speed.

V. CONCLUSION

The results showed a significant decline in memory functions pre- and post-disease onset. Executive functions also declined visibly, although the change was not statistically significant. These findings suggest that Lyme neuroborreliosis can adversely affect cognitive abilities, supporting the study's objective of evaluating its impact on pilots' neurocognitive functions. However, the failure to reject the null hypothesis for executive function highlights the complexity of fully understanding the specific cognitive impairments caused by Lyme neuroborreliosis. This case study emphasizes the need for further research with larger sample sizes and control groups to better characterize the cognitive challenges faced by individuals with Lyme neuroborreliosis, especially in the aviation industry. Such research will support the development of targeted interventions and support systems for affected pilots.

LIMITATION

The primary limitation of this study is the small sample size, as Lyme neuroborreliosis is rare, especially among pilots. This limits the generalizability of the findings. Additionally, focusing on a single age group (60-year-old pilots) restricts the applicability of results to other ages and professions. The methodology, which compares cognitive function before and after Lyme neuroborreliosis, may not fully account for external factors or confounding variables influencing cognitive performance over time. While the study offers valuable insights into the cognitive impact of Lyme neuroborreliosis, these limitations emphasize the need for broader research. Future studies should include larger and more diverse participant groups, use comprehensive assessment tools, and consider a wider range of variables to strengthen the robustness and relevance of the findings.

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