Research Article

Effects of 8-week yoga therapy on vision and quality of life in COVID-19 vaccine-associated optic neuritis: A case series study

Elmira Ahmadi[1,2], Shahnaz Shahrbanian[2*]

Abstract

While COVID-19 vaccines have reduced the prevalence of new viral strains, they are associated with side effects, including optic neuritis (ON). Developing effective management strategies, particularly non-pharmacological interventions, may improve outcomes for affected patients. This case study evaluated the effects of 8 weeks of yoga therapy in two male patients, aged 58 and 43, who developed ON two weeks post-vaccination. Assessments included visual field and color perception tests, the Balance Error Scoring System (BESS), the National Eye Institute Visual Function Questionnaire (NEI VFQ-25), and the Beck Depression Inventory II (BDI-II). Results from the yoga therapy patient were compared to a control case. The yoga therapy patient showed marked improvements: visual field enhancements of 48% (left eye) and 42% (right eye), a 53% increase in color perception, and a 31-turn improvement in the 6-Minute Walk Test. BESS errors reduced, heart rate recovery improved by 22 beats per minute, NEI VFQ-25 scores rose, and BDI-II scores declined. The control patient experienced no changes. Yoga therapy may complement pharmacological treatments for ON, offering benefits through anti-inflammatory effects, HPA axis modulation, and neuroprotective mechanisms that support remyelination. The integration of exercise and medication, termed "MedXercise," shows potential for managing vaccine-related side effects. Further research should explore varied exercise regimens to confirm these findings.

Key Words: **Yoga therapy, COVID-19, Optic neuritis, Vaccination, Visual field, Sports medicine**

1. School of Human Kinetics and Recreation, Memorial University in Newfoundland and Labrador (Canada). 2. Department of Sport Sciences, Faculty of Humanities, Tarbiat Modares University, Tehran, Iran.

*Author for correspondence: sh.shahrbanian@modares.ac.ir

E A: 0000-0002-5675-7761; S SH: 0000-0003-3104-7584

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Introduction

COVID-19 disrupts the immune system, long-term infection can lead to physiological changes, including reduced muscle strength and endurance, diminished quality of life, and, in some cases, death. Consequently, strategies to prevent these outcomes have become a major focus of research (Knoll & Wonodi, 2021a; Suzuki et al., 2022). Although various methods to prevent COVID-19 were explored, their effectiveness was limited, leading researchers to prioritize the development of vaccines. Concerns remained regarding its use, particularly due to the irreversible side effects associated with some COVID-19 vaccines (Sallam, 2021). By January 20, 2021, a total of 173 COVID-19 vaccines were being developed, with 64 of them undergoing clinical trials (Medeiros et al., 2022). Although the side effects of vaccines have been well-known for some time, vaccines remain the only effective defense against deadly diseases. However, while some of the vaccines developed had few side effects, others were associated with a greater number of adverse effects (Medeiros et al., 2022). One of the side effects of the COVID-19 vaccine is optic neuritis (ON), which was found to be the most common in a group of 55 patients diagnosed with this condition (Alvarez et al., 2021; Leber et al., 2021). Optic neuritis is believed to result from inflammatory, autoimmune, or infectious disorders (García-Estrada et al.2022). Optic neuritis, the most common syndrome affecting the nervous system, transmits visual signals from the back of the eye to the brain. The demyelination seen in optic neuritis occurs through the activation of T lymphocytes, which ultimately leads to the release of cytokines and inflammatory factors (Xue et al., 2021).

It has been observed that optic neuritis can occur following various vaccinations, including those for hepatitis A and B, influenza, and measles, due to factors such as immune responses. While the exact cause of the disease remains unknown, the side effects of these vaccines may trigger autoimmune or demyelinating conditions (Cheng & Margo, 2021). However, after the use of certain COVID-19 vector vaccines, there have been reports of optic neuritis (ON), althou-

-gh the underlying mechanisms remain unknown (García-Estrada et al.2022). Certain substances in the vaccine can activate the NLRP3 inflammasome, leading to the stimulation of inflammation and immune responses (Teijaro & Farber, 2021). Therefore, optic neuritis typically presents as a sudden onset of vision loss accompanied by eye pain during movement, and the condition often worsens over the course of a week, reaching its peak severity (Arnao et al., 2022). Given that the side effects of these vaccines are known, it is important to prioritize strategies for their rapid recovery. Some studies caution that exercise should be approached with care during illness (Hekmatikar et al., 2021; Shahrbanian et al., 2020). It has been shown that during illness, exercise intensity should be low, and its duration should not exceed 20 minutes (Hekmatikar et al., 2021). Given the uncertain nature of COVID-19 and the side effects of COVID-19 vaccines, yoga exercises appear to be a suitable option. Yoga has been shown to enhance blood circulation and nutrient delivery to the eyes through various postures, thereby promoting eye health (Desai et al., 2020), Additionally, yoga induces an anti-inflammatory effect by modulating the sympathetic signaling pathway (Cutter et al., 1999; Plotnik et al., 2020), Yoga can to reduce inflammation, alleviate stress, and promote the release of brain growth factors, making it particularly beneficial for individuals with mobility impairments (Ziemann et al., 2002) . An important consideration is that yoga may help address spasticity or muscle stiffness through the release of GABA, an inhibitory neurotransmitter, which could impact the affected areas of the spinal cord. Proper movement patterns and muscle activation rely on a balanced interaction between the neurotransmitters GABA and glutamate. In people with ON, glutamate levels are elevated in the central nervous system, leading to increased excitability and impaired motor function (Cramer et al., 2013). Suggests that yoga may enhance the synergistic effects of medications. Additionally, yoga practice to improve the perception of visual geometry, such as the visual field (Koenderink et al., 1978). Finally, in this case study, two patients with side effects from the COVID-19 vaccine participated in a yoga training protocol, while the other patient served as a control. This study design is typically used when the disease is rare and new, the observed event is severe, and there is limited opportunity for further research during the critical period (Thomas et al., 2013). The aim of the present study is to address the scientific gap by better understanding the concept of MedXercicse (describe a combination of medication and exercise(Ploughman et al., 2022) and yoga exercises for patients with optic neuritis (ON), as well as exploring the potential synergistic effects of drug therapy in response to vaccine side effects.

Materials and Methods

Inclusion and exclusion criteria

The following inclusion and exclusion criteria were applied to select participants for this study: Inclusion criteria for participants: Age between 30 and 60 years, diagnosis of optic neuritis confirmed by a neurologist and ophthalmologist, ability to perform physical activities, BMI below 30, No history of depression or other medical conditions

Exclusion criteria: If the patient is unwilling to continue during the training period or if their condition worsens, inability to perform yoga exercises, medical unfitness for continuing the exercises, as determined by the treating physician, changes in the patient's condition or prescribed medication.

Participants

The first participant was a 58-year-old man with no prior medical history. He weighed 88 kg, stood 176 cm tall, had a blood pressure of 100/60 mmHg, and a resting heart rate of 88 beats per minute. He tested negative for COVID-19 by nasopharyngeal polymerase chain reaction (PCR). Two weeks after receiving the COVID-19 vaccine in Iran, he was diagnosed with bilateral optic neuritis (ON), and vision loss occurred progressively in both eyes. The diagnosis was confirmed by neurologists and the Iranian medical system as a complication of the vaccine. Given the importance of COVID-19 vaccination during the pandemic, understanding its side effects and finding solutions for those affected became crucial. The patient was discharged from a hospital in Tehran with severely impaired vision. He had undergone a lumbar puncture for a cerebrospinal fluid (CSF) test, which ruled out multiple sclerosis, and received treatments including 11 doses of corticosteroids, 125 g of intravenous immunoglobulin (IVIG), and plasmapheresis over the course of a month. Due to the similarities between the visual dysfunction caused by the vaccine and the symptoms of multiple sclerosis and optic neuritis, the researcher decided to explore treatment options from existing literature for this patient's condition.

The second participant was a 43-year-old man with no prior medical history. He weighed 95 kg, stood 190 cm tall, had a blood pressure of 120/60 mmHg, and a resting heart rate of 76 beats per minute. He tested negative for COVID-19 by nasopharyngeal polymerase chain reaction (PCR). Ten days after receiving the second dose of the COVID-19 vaccine in Iran, he was diagnosed with unilateral optic neuritis (ON), with progressive vision loss in the left eye. The diagnosis was confirmed by neurologists and the Iranian medical system as a complication of the vaccine. The patient was discharged from a hospital in Tehran with severely impaired vision in the left eye. He underwent a lumbar puncture for a cerebrospinal fluid (CSF) test, which ruled out multiple sclerosis, and received 10 doses of corticosteroids, 125 g of intravenous immunoglobulin (IVIG), and plasmapheresis over the course of one month.

Ethical considerations

In accordance with the study protocol, informed consent was obtained from the patient, and the exercise regimen was carried out. The consent form clearly explained all the steps and training protocols in simple, honest language, alongside the standard treatments provided at the hospital. The patient signed and approved the consent form, indicating their agreement. Additionally, the ethics approval for this project, with the code IR.MODARES.REC.1400.353, was granted by the Research Ethics Committee of the Research Institute of Physical Education and Sports Sciences.

Initial evaluation

Before beginning the research protocol, the patients were evaluated by an ophthalmologist in Tehran, who assessed their visual field using an eye perimetry device at 6 meters. Anthropometric measurements, including height, weight, and blood pressure, were also taken. Additionally, the patients completed the consent form with the assistance of the researcher.

In the case involving yoga practice, the Ishihara Color Test was administered to the participant using software on an Asus laptop. During the introductory session, the researcher and a neurologist guided the participant through the study procedures, and the participant completed the NEI-VFQ25 (National Eye Institute Visual Function Questionnaire) and the BDI-II (Beck Depression Inventory-II) with the researcher's assistance. In the pre-test session, the participant undertook the BESS (Balance Error Scoring System) balance test with both eyes open and closed. Twenty-four hours later, the participant completed the 6-Minute Walk Test (6MWT) over a 20-meter course while monitored by a smartwatch. Following another 24-hour period, the initial yoga session was conducted in the presence of the participant, researcher, physician, and instructor.

Exercise protocol

A professional yoga instructor (Holder of a CYT certificate in yoga therapy) guided the participants through each in-person yoga session, also the researchers of the present study were also present at all meetings. Each session included a 10-minute warm-up and meditation phase, followed by a 30-minute training sequence encompassing a variety of poses—such as ocular exercises, forward bends, backbends, side bends, balance postures, and reverse movements—and concluded with a 10-minute cool-down. These sessions were conducted three times per week over an 8-week period. The ocular exercises practiced in each session included palming, blinking, sideways viewing, front and side viewing, diagonal viewing, rotational viewing, preliminary nose-tip gazing, near and distant viewing, concentrated gazing (Trataka), and stimulation of a specific acupressure point on the palm (Gupta & Aparna, 2019; Kim, 2016). The routine thus combined exercises aimed at enhancing ocular motility, focus, concentration, purification, and relaxation. For both the initial assessment, the exercise sessions, and the follow-up assessment, participants were seated in the same chair, maintaining a stable posture with their head, neck, and body kept still (Bianchi & Bellen, 2020). The body movements incorporated classic Iyengar yoga techniques, utilizing props such as chairs, straps, resistance bands, and mats (Table 1). Each pose was held for 10–30 seconds, with approximately 30 seconds of rest between each. These poses were organized into three categories—standing, seated, and lying—allowing for a progression from easier to more challenging levels (Kishiyama et al., 2002). The participant gradually advanced from simpler poses to more challenging ones with each subsequent session. As the program progressed, movements were reversed, and the rest period between each pose was extended from 30 seconds to 2 minutes (Najafi & Moghadasi, 2017). Consistent training sessions were crucial to the program's success. Classes took place in a quiet room, featuring a standardized set of yoga postures and stretches, with an ambient temperature maintained between 23°C and 25°C.

Table 1. Yoga poses taught in the sessions.

Workout	Rounds *Time (second)
Breath work	3 * 10
Arms overhead stretches	3 * 15
Mountain pose (seated)	3 * 20
Eagle pose	2 * 15
Ankle on Knee Forward Bend	2 * 15
Warrior II on chair	3 * 10
Side Angle Pose	3 * 15
Seated Twist	3 * 20
Tree Pose	3 * 10
Triangle Pose	3 *10
Supported downward dog	3 * 15
Reclining Bound Angle	2 * 15
Cat pose	3 * 10
Pose of a Child	3 * 15
Diagonal Stretch	2 * 20
Hand to Toe	2* 10
Supported Back Bend	2 * 15
Rising Sun Twist	2* 15
Legs up Wall	3* 10
Relaxation	-

Figure 1. Perimetry test

Outcome measures

Perimetry test

Perimetry is a technique used to assess visual field function by measuring responses to various types and intensities of stimuli. It can involve dynamic targets that trace the boundaries of the visual field or static targets that measure the sensitivity across different regions of the field. The visual field encompasses the entire area visible to each eye, including both central and peripheral vision. Perimetry can be customized to evaluate either the central visual field, the peripheral visual field, or both. Typically, the central visual field is given special attention, as approximately 60% of all retinal nerve fibers originate from the central 30 degrees of the visual field (Rowe, 2016). As a result, the assessment of the central visual field is particularly important, as most visual field loss is attributed to common ophthalmic diseases affecting this area. On the other hand, peripheral visual field testing is crucial when pathology is known to impact the regions outside the central 30 degrees. However, it is important to note that up to 25% to 50% of nerve fibers can be lost before a defect in the visual field becomes detectable through perimetry (Quigley et al., 1989). The participants sat comfortably in a chair, positioned 6 meters away from the screen, and were instructed to focus on a red fixation cross at the center of the stimulus pattern. The screen was placed 30 cm away, corresponding to a total stimulus subtending to an angle of 52 degrees. This test assesses the function of the optic nerve and visual cortex. An ophthalmologist administers the test, where the patient's head is positioned in the device, and the opposite eye is closed. Blinking points on the device are activated, and the participant is required to signal each time a light appears. The participant must maintain a steady gaze, as the test will stop if an error occurs (Hepworth & Rowe, 2018). As you can see in the Figure 1, the perimeter operation was performed with a Zeiss device.

Computer-based Ishihara test

The Ishihara test for color blindness was conducted using the first 21 plates from a new set of Ishihara color vision deficiency examination plates. These plates were scanned using an ASUS all-in-one scanner with a resolution of 600 x 800 dip, with no adjustments or modifications made to the scanned images. The volunteer sat 75 cm from the monitor, and the test began when the participant pressed the "Start" button on the initial screen, which displayed the first plate along with instructions on how to use the test. After answering the first question, the next plate was shown for 3 seconds, after which the image disappeared, and the participant was instructed to record the numeral in the specified space before moving on to the next plate. Upon completing all 21 plates, the program compiled the results, indicating which answers were correct, which were incorrect, the participant's final score, and a diagnostic conclusion based on the instructions sheet (Marey et al., 2015).

Six-minute walk test (6MWT)

The six-minute walk test (6MWT) has a well-established history for assessing walking capacity in both clinical and research settings. This test should be conducted indoors, along a long, flat, straight corridor with a hard surface, ideally one that is seldom used by others. The walking course is typically 20 meters in length, requiring a corridor of at least 100 feet. The corridor should be marked every three meters, with turnaround points indicated by cones. Additionally, a brightly colored tape should be used to mark a starting line on the floor, which also serves as the endpoint for each 60-meter lap (Chaudhari & Mahulkar, 2019). The use of a treadmill for the six-minute walk test (6MWT) is not recommended. A warm-up period before the test should be avoided. Prior to beginning, the participant should sit at rest in a chair near the starting position for at least 10 minutes. During this time, assess any contraindications, measure heart rate, pulse, and blood pressure, and ensure that the participant's clothing and shoes are appropriate. Throughout the test, stay near the starting line but do not walk alongside the participant. Start the timer as soon as the participant begins walking, and refrain from speaking to them during the test. After the test, record the number of laps completed using the counter and calculate the total score by multiplying the number of laps by distance. Finally, at the end of the test, evaluate and record the participant's fatigue level using the Borg scale.

Balance error scoring system (BESS)

The test consists of three positions performed on both stable and unstable surfaces using the dominant leg. The first position involves standing on both feet. The second position requires standing on the non-dominant leg with the dominant leg flexed at 30 degrees at the thigh and 45 degrees at the knee. The third position involves standing with both feet in a straight line, where the heel of the front foot touches the toe of the back foot, with the front foot ahead and the non-dominant foot behind. In all positions, the participant's eyes are closed, and their hands are placed on the waist. Each position is held for 20 seconds (Bressel et al., 2007; McGuine & Keene, 2006). The score was determined by recording errors, which included: opening the eyes, removing the hands from the waist, the foot not in contact with the ground touching the surface, swaying or stepping, any movement of the standing foot, lifting the toe or heel off the ground, excessive abduction or inward movement of the thigh beyond 30 degrees, and remaining out of position for more than five seconds.

National eye institute visual function questionnaire (NEI VFQ-25)

It can be used to assess the quality of life in patients with ocular conditions (Asgari et al., 2011). The Persian version of this questionnaire is valid and acceptable for assessing the quality of life in individuals with eye diseases. When combined with the pat-

-ient-partner method, both the patient and their partner participate in the assessment, providing a more comprehensive evaluation of the impact of the condition on daily activities, emotional well-being, and overall quality of life.

This combined approach offers a broader perspective by considering both the patient's experience and the partner's observations (Asgari et al., 2011; Sugawara et al., 2010). Cronbach's Alpha was above 0.7 for all subscales of the questionnaire, except for the driving subscale (Asgari et al., 2011). This questionnaire assesses various aspects of a person's life, including general health, visual health, mental health, eye pain, long-distance activities, near vision activities, social functioning, peripheral vision, color vision, limitations in performing activities, driving, and dependence. It consists of 25 questions, with responses converted into a score ranging from 0 to 100, where 0 represents the worst quality of life and 100 represents the best. The overall quality-of-life score is the average of the individual item scores, with higher scores indicating a better quality of life (Azizi[1] et al., 2018). The questionnaire was completed by researcher.

Beck depression inventory – II (BDI-II)

BDI-II consists of 21 groups of questions. the correlation coefficient of this questionnaire was calculated to be 81.2%, the reliability of this questionnaire is 0.93, and split-half is 0.64 (Hamidi et al., 2015). these questions assess various symptoms, including sadness, pessimism, feelings of failure, dissatisfaction, guilt, desire for punishment, self-loathing, self-blame (including self-harm and crying), irritability, social isolation, body image changes, laziness, sleep disturbances, fatigue, weight loss, decreased appetite, rumination, and reduced sexual potency. Each symptom is scored on a scale from 1 to 4, where 1 represents the mildest and 4 the most severe aspect of the symptom, with the total score indicating the severity (Hamidi et al., 2015). The questionnaire was completed by the researcher, in combination with the patient-partner method. Both the patient and their partner contribute to the assessment, providing a more comprehensive understanding of the emotional and psychological impact of the condition on the individual's life. This combined approach allows for a broader evaluation, considering both the patient's self-reported experience and the partner's observations.

Heart rate recovery

Heart rate (HR) recovery is a significant prognostic factor that predicts total mortality, as well as cardiovascular and non-cardiovascular deaths, in a primary prevention cohort (Sydó et al., 2018). In response to exercise stress, the medulla-adrenergic-sympathetic pathway regulates heart rate through changes in catecholamine release. Studies on exercise monitoring have shown that heart rate (HR) and the rating of perceived exertion (RPE) during activity are closely related internal indicators. Monitoring one of these parameters during training sessions can provide insights into changes in the other, offering valuable information about the body's response to exercise (E. Ahmadi et al., 2020). Recovery heart rate was calculated by determining the difference between the heart rate at the end of the training session and the heart rate one minute after training (Assaf et al., 2021). The heart rate was measured using a smartwatch at the end of the training session, and again one minute after the session concluded. The heart rate drop between the two measurements was recorded as an indicator of recovery rate for each post-workout session.

Statistical analysis

The Shapiro-Wilk test was used to check the normality of the data, and the Levene test was used to check the equality of variance of the variables. The repeated measures ANOVA test with the between-group factor was used to compare the groups. Data analysis was performed using SPSS version 27 software, and the significance level was set at $P \leq 0.05$.

Results

Two patients with optic neuritis side effects from the COVID-19 vaccine participated in the research protocol of the present study. The details and characteristics of the patients are specified in Table 2 and 3. The statistical method of the case-control study was carried out by the percentage comparison method.

Clinical results

The results indicated that, after performing the exercise protocol, the perimetry results for Case Study (visual field) showed improvements. For the left eye, the perimetry score changed from -32.17 to -16.75 (a 47.93% improvement), and for the right eye, the score improved from -32.14 to -18.58 (a 42.19% improvement). In contrast, the perimetry results for the control ca-

Table 2. Characteristics outcomes

Characteristics	Outcomes
	Case study
Age	58 years
Height	176 cm
Weight	88 kg
Gender	Male
Blood pressure	100.60 mmHg
Heart rate rest	88 beats per minutes
Clinical diseases	Negative
COVID-19	Negative
Length of stay at the hospital	30 days
Type of vaccine received	Vector vaccine
Vision problem	negative
Neuromuscular disease	negative
Medicine	Prednisolone, Xalerban

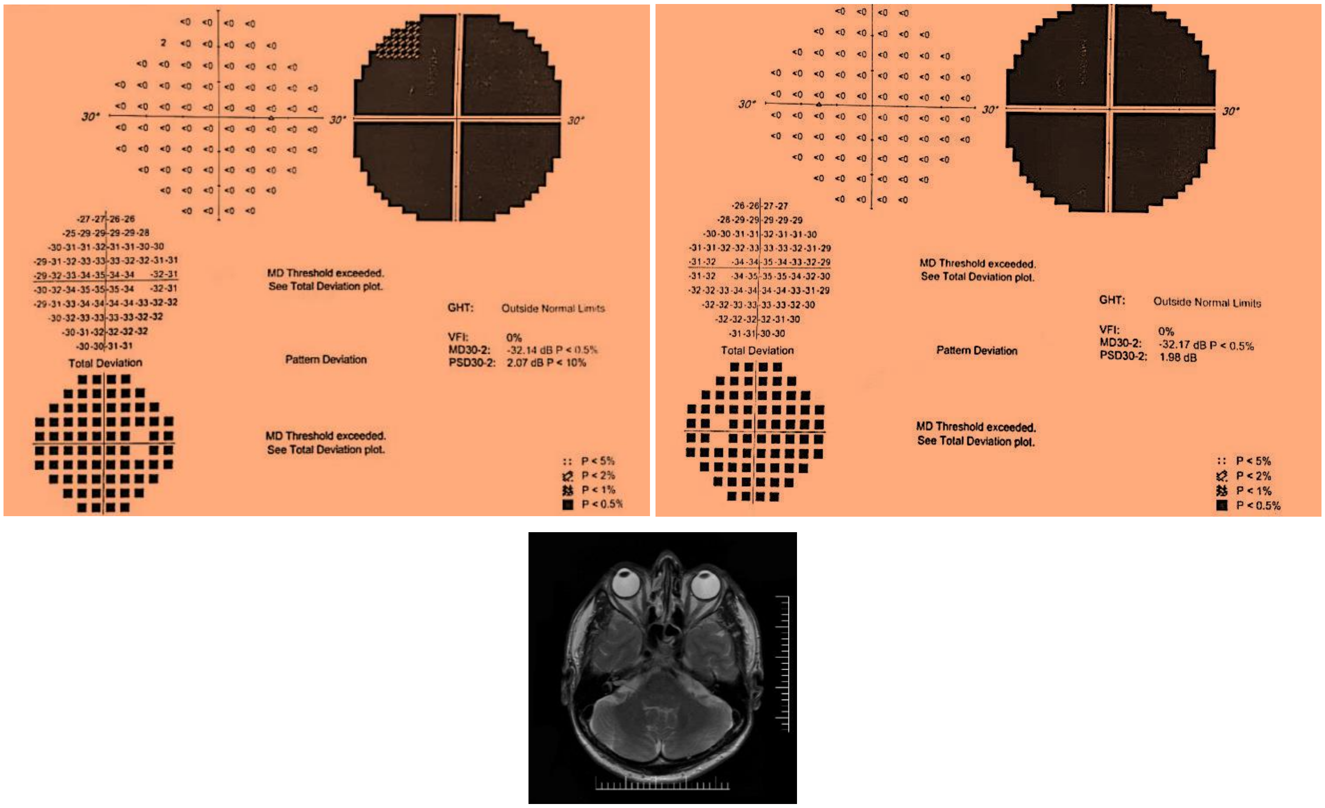

Figure 2. The impression of optic neuritis is shown by the perimetry of the right and left eye and the MRI image.

-se (Case Control), where there was no vision problem in the right eye, showed no significant change, with the left eye score changing slightly from -19.22 to -19.41 (0% change).

Practical result

The results indicated significant improvements across multiple tests after the exercise protocol. In the Ishihara test (color perception), the participant improved from 0 correct answers out of 18 to 9 correct answers out of 18. The 6-minute walk test sho-

Table 3. Patient's characteristics no training

Characteristics	Outcomes
	Control Study
Age	43 Years
Height	190 CM
Weight	95 KG
Gender	Male
Blood pressure	120.60 mmHg
Heart rate rest (beats per minutes)	76 beats per minutes
Clinical diseases	Negative
COVID-19	Negative
Length of stay at the hospital	40 days
Type of vaccine received	Vector Vaccine
Vision problem	Negative
Neuromuscular disease	Negative
Medicine	Prednisolone, Xalerban

-wed an increase in walking capacity, with the participant completing 31 laps on the 20-meter path, compared to 19 laps initially, leading to an improvement in their score from 380 to 620. Additionally, the participant's performance on the BESS balance test improved, reducing errors from 7 on flat surfaces and 9 on foam to 2 on flat surfaces and 3 on foam, indicating better balance. Cardiovascular function, assessed by heart rate recovery after each session, showed improvement. The recovery rate increased by 54%, with the heart rate drop improving from 20 beats per minute in the first session to 44 beats per minute in the last session (session 24), meaning the participant's heart rate returned to baseline 54% faster after the training period. The NEI VFQ-25 (National Eye Institute Visual Function Questionnaire) showed significant improvements in several areas, including health and general vision, difficulty performing activities (improving from 280 to 1120), and response to vision problems (improving from 80 to 820). The total score for the questionnaire increased from 535 to 2215, indicating a significant improvement in the participants' quality of life. In the BDI-II (Beck Depression Inventory-II) questionnaire, which assesses symptoms of depression, the participant's depression score decreased significantly from 61 to 35 after the exercise period, indicating a reduction in depressive symptoms (Figure 2 & 3).

Discussion

In this study, we reported two male cases of visual neuritis follow-

following COVID-19 vaccination. As COVID-19 vaccination continues to be administered globally, it is expected that some side effects will emerge. Among these vaccines, vector-based vaccines are particularly cost-effective and easy to maintain, making them widely used across the world (Knoll & Wonodi, 2021b). It is essential for individuals to be informed about potential risks while also understanding the overall benefits of vaccination in controlling the spread of the virus (Knoll & Wonodi, 2021b). This increase in vaccination efforts may lead to an uptick in side effects, making it imperative for scientific research to prioritize strategies aimed at preventing or mitigating these adverse effects.

A)

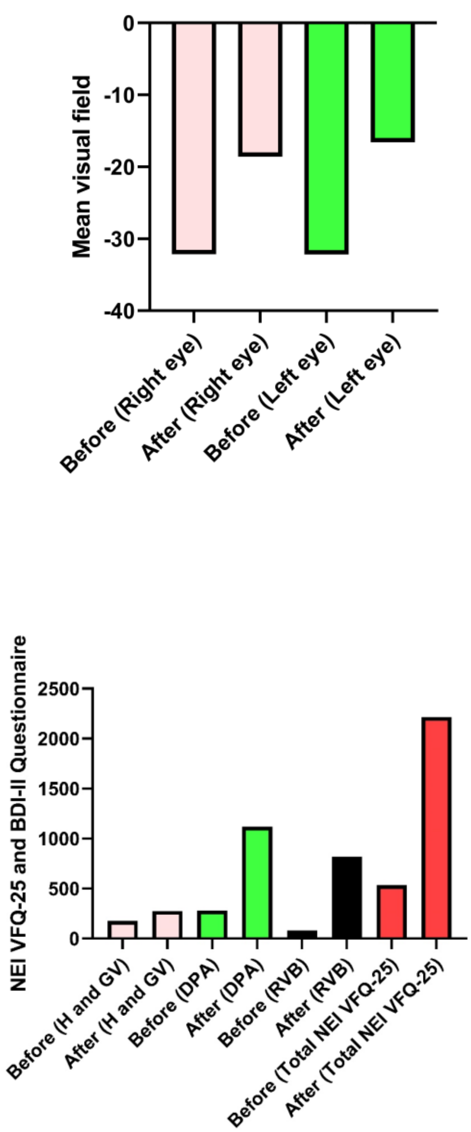

Figure 3. The perimetry and Ishihara Test factors, NEI VFQ-25 and BDI-II Questionnaire (A & B). H and GV: Health and general vision, DPA: Difficulty performing activities, RVP: Response to vision problems

We hypothesize that the vaccine may trigger an autoimmune response, potentially leading to the development of optic neuritis. Previous studies have documented cases of optic neuritis (ON) in individuals who have received the vaccine, suggesting a possible link between vaccination and the onset of this condition (H. A. H. Ahmadi et al., 2020; Azab et al., 2021; Benito-Pascual et al., 2020; Leber et al., 2021; Parvez et al., 2021; Sinha et al., 2021). The exact cause of optic neuritis (ON) remains unclear, but it is believed to involve an immune-based pathogenesis triggered by viral infections, leading to demyelination of the optic nerve. In the present study, the side effects of optic neuritis were observed to include decreased visual field, reduced color perception, impaired balance, and decreased physical function.

We aimed to establish a safe exercise protocol for individuals with optic neuritis to help mitigate its side effects. Traditional therapies have long been the cornerstone of eye care, emerging evidence highlights the benefits of integrative approaches, which can complement the management of optic neuropathy. Yoga is a mind-body practice that includes postures, controlled breathing, and meditation. It is gaining attention for its holistic effects on well-being, promoting health, preventing disease, aiding in disease management, and offering rehabilitative potential (Tiwari et al., 2023). Thus, we chose yoga exercises to create a safe and effective protocol for individuals with optic neuritis. Our decision to incorporate yoga was based on its ability to reduce stress and its low-intensity nature, making it suitable for those recovering from or managing conditions like optic neuritis. Recent findings suggest that yoga can enhance immune system function, further supporting its potential benefits in improving overall health and well-being (Estevao, 2022), Yoga therapy interventions have been shown to improve brain health in neurological disorders, such as multiple sclerosis (MS), by promoting several beneficial processes. These include increasing oxygenation in the brain, enhancing neurotrophic factors, stimulating angiogenesis, and achieving a balance between inhibitory and stimulatory neurotransmitters. also Zikang et al. (2022) examining the types of sports activities for patients with balance impairment demonstrated that yoga yields better results than other forms of exercise in improving balance (Hao et al., 2022).Yoga also helps balance pro-inflammatory and anti-inflammatory cytokines, promotes effective immune responses, and prevents oxidative stress. These combined effects contribute to greater brain synapse flexibility, improved cognitive function, and increased myelination in key brain regions, including the limbic system, anterior cingulate cortex, and dorsolateral prefrontal cortex (Lehmann et al., 2001; Pickut et al., 2013). Although yoga alone may not directly impact the recovery process in optic neuritis (ON), it has been shown that physical activity, including yoga, can enhance the synergy between exercise and drug therapy in improving recovery outcomes for COVID-19 patients.

This combined approach can potentially optimize overall recovery, supporting the healing process and mitigating symptoms more effectively when used alongside medical treatments (Hekmatikar et al., 2021), The benefits of high-dose intravenous immunoglobulin (IVIG) administered at a high infusion rate have been well-documented in studies, particularly for inflammatory diseases. Research has demonstrated that this treatment can significantly reduce inflammation, modulate immune responses, and improve clinical outcomes in conditions such as optic neuritis, autoimmune diseases, and other inflammatory disorders. The rapid administration of high-dose IVIG has shown great effectiveness in managing the acute phases of these diseases, providing substantial therapeutic benefits (Danieli et al., 2021). Indeed, modulating the immune system's response to inflammation is the primary therapeutic target of intravenous immunoglobulin (IVIG). By providing pooled immunoglobulins from healthy donors, IVIG works to regulate immune function, suppress excessive inflammatory responses, and restore immune system balance. This modulation can help reduce tissue damage caused by autoimmune and inflammatory diseases, making IVIG an essential treatment for conditions like optic neuritis, Guillain-Barré syndrome, and various other immune-mediated disorders (Kumar et al., 2021), IVIG is a promising therapeutic candidate that can operate at multiple levels with various synergistic mechanisms, thereby restoring immune system homeostasis (Kohler & Kaveri, 2021). IVIG has been shown to be effective in controlling and increasing muscle strength, leading to improvements in disability associated with autoimmune and inflammatory neuromuscular diseases (Sala et al., 2018).

Therefore, it appears that physical activity tailored to the patient's condition can synergistically enhance the recovery process and improve patient performance. The results of this study, which compare the progress of Case 1 (who engaged in yoga practice and experienced partial recovery) with Case 2 (who rested without exercise and remained under observation), further support the notion that yoga therapy, in addition to conventional drug therapy, can have a more effective impact on recovery. The case study demonstrated improvement in optic neuritis (ON) after eight weeks of yoga exercises. It appears that yoga, in synergy with drug therapy, contributed to enhanced vision and color perception during 8-weeks intervention. This improvement may be attributed to positive changes in eye function, as other studies have shown that maintaining eye health can be supported through yoga exercises (Hart et al., 2022), However, given that the sample size was very small and the research was only conducted on men, it cannot be generalized to the general public at this time and requires the results of future research, , further research is needed to fully validate these findings and establish the therapeutic efficacy of yoga in managing ON.

We carefully monitored exercise intensity using heart rate monitoring and the Borg scale to avoid overexertion and stress, which could be a key strength of the present study. Given that the specific signaling pathway of yoga on optic neuritis has not yet been established, we present a potential hypothesis. Bilateral optic neuritis is a rare occurrence, typically associated with demyelination driven by immune system dysfunction. In such cases, the patient may experience a gradual loss of vision along with impaired eye movement (De la Cruz & Kupersmith, 2006). Demyelination and axonal reduction in optic neuritis occur as a result of T cell activation, which ultimately triggers the release of cytokines and other inflammatory factors. These immune-mediated processes contribute to the damage of the optic nerve, leading to visual impairments and potentially affecting eye movement (Plotnik et al., 2020).

Considering that optic neuritis impacts the optic nerve and based on previous studies on yoga's effects on the brain, it is possible to hypothesize the potential signaling pathways through which yoga could influence optic neuritis. Yoga exercises can help calm the nervous system, reduce stress, alleviate muscle tension, and regulate anxiety levels by modulating the sympathetic nervous system and vague nerve activity. An RCT study in India, in a group of neurological patients who performed yoga exercises, functional infrared spectroscopy showed increased blood flow, followed by oxygenation, and reduced levels of inflammation in the prefrontal cortex (Gagrani et al., 2018). Furthermore, yoga therapy, may play a role in balancing endocrine hormones and minimizing the impact of the hypothalamic-pituitary-adrenal (HPA) axis. One important aspect of yoga's impact is its ability to address spasticity and muscle stiffness, potentially through the release of GABA (gamma-aminobutyric acid), an inhibitory neurotransmitter that helps regulate muscle tone and movement. The balance between GABA and glutamate, an excitatory neurotransmitter, is essential for proper muscle activation and movement patterns. In individuals with optic neuritis (ON), glutamate levels are often elevated in the central nervous system, which can lead to increased excitability, spasticity, and impaired motor function (Cramer et al., 2013). By helping to regulate these neurotransmitters, yoga may mitigate the effects of glutamate's overactivity and promote better motor function. Furthermore, yoga's anti-inflammatory effects, through modulation of pro-inflammatory cytokines, could help reduce the inflammation that exacerbates ON symptoms, making it a complementary approach to managing ON (Gagrani et al., 2018).

Asana programs in yoga designed to improve eye function and stimulate the optic nerve have shown positive effects in overcoming eye-related disorders. These practices help reduce mental stress, enhance concentration and memory, and promote muscle relaxation. Eye yoga, in particular, is beneficial for stimulating the optic nerve, which contributes to overall eye heal-

-th and function, making it one of the most effective methods for improving vision-related issue (Melief et al., 2013). It has been shown that yoga can affect the hypothalamus, playing a role in regulating anti-stress factors. Research related to multiple sclerosis (MS), a neurological condition where optic neuritis (ON) is a common disorder, suggests that higher levels of stress are associated with increased activity of plaques and greater demyelination in nerve pathways. Therefore, yoga's stress-reducing effects may be beneficial in managing MS and optic neuritis by potentially slowing the progression of nerve damage through its influence on stress levels (Melief et al., 2013). Yoga improves mental health through multiple mechanisms, including the stimulation of the central nervous system, the release of endorphins, monoamines, and brain-derived neurotrophic factor (BDNF) in the hippocampus. These effects contribute to better mood regulation, reduced stress, and enhanced cognitive function, which can support overall neurological health and potentially aid in the recovery process of conditions such as optic neuritis (Babyak et al., 2000). Studies have shown that in women over 60 years old with a history of practicing yoga, there was an increase in cortical thickness and gray matter (GM) volume. Additionally, greater cortical thickness was observed in the left frontal cortex in the group that practiced yoga, suggesting that regular yoga practice may contribute to improvements in brain structure and function, particularly in regions associated with cognitive processes and emotional regulation (Gothe et al., 2019). It has also been suggested that yoga exercises may indirectly enhance working memory. This improvement is thought to result from the combined effects of reduced stress, increased concentration, and better regulation of emotional responses, all of which can positively influence cognitive functions such as memory retention and processing (Garner et al., 2019). Yoga exercises, along with meditation and breathing techniques, not only improve physical and cardiovascular fitness but also promote mindfulness and offer neuroprotective benefits. These practices have been shown to support mental well-being, which is particularly important for individuals recovering from COVID-19 (Gothe et al., 2019), The cerebellum, which plays a key role in coordination and timing of movements, is positively influenced by yoga, leading to improvements in executive functioning (Llinás & Welsh, 1993), All of these findings align with the results of the present study. Additionally, considering the increase in neuroinflammation associated with this condition, yoga seems to help reduce inflammation due to its low-intensity and relaxing nature (Rogers & MacDonald, 2015). While yoga alone may not be expected to directly improve immune system function, it can help reduce inflammation by lowering cortisol levels. This process, combined with drug therapy, may contribute to improving optic neuritis.

An imbalance in walking and a decrease in the 6-minute walking test were observed, which appear to have resulted from optic ne-uritis (NO). After 8 weeks of yoga exercises, these issues likely improved through the synergistic effect of yoga and drug therapy. Research has demonstrated that exercise can enhance balance, which may occur through improved vision and exercises performed in various positions (Nick et al., 2016; Solakoglu et al., 2022; Thakkar et al., 2021). No study was found specifically examining the 6-minute walking test in patients with optic neuritis, and it is possible that this type of test is more commonly used in the rehabilitation of patients with COVID-19. Furthermore, yoga exercises are not yet included in the rehabilitation protocols for these patients. Therefore, one of the strengths of this case study is the introduction of yoga as a potential rehabilitation protocol for COVID-19 patients. Additionally, other positive outcomes, such as improved heart rate, faster recovery rates, and reduced post-yoga depression, were observed. These results align with the known benefits of yoga, particularly its ability to reduce depression and stress, which in turn may contribute to improvements in heart rate and recovery (Gonzalez et al., 2021).

In conclusion, yoga has demonstrated promising benefits for improving eye health, particularly in reducing stress, enhancing blood flow, and lowering inflammation, all of which contribute to better visual function. The integration of yoga with conventional treatments has shown positive effects on quality of life and overall well-being (Gagrani et al., 2018). While the evidence is encouraging, further research is needed to fully understand the most effective methods and protocols for incorporating yoga into the management of eye conditions. Continued exploration of this integrative approach could lead to more comprehensive treatment strategies for ocular health. In fact, the concept of MedXercise allows for the concurrent use of exercise and medication to improve recovery and manage disease conditions effectively (Lozinski & Yong, 2022).

Conclusions

Vaccines have several potential side effects, one of which was examined in the present study. While most sports science research has focused on post-COVID-19 rehabilitation exercises, it is important to recognize that vaccine side effects can also be significant and, in some cases, dangerous. Therefore, there is a need for the development of sports research protocols aimed at improving and evaluating these vaccine side effects. We suggest that integrating practices such as yoga alongside medication could be a key area for future research, as it may help mitigate and evaluate the impact of vaccine side effects.

Limitation and future prospective

This study has some limitations. Because of the COVID-19 pandemic and limited vaccine availability, we could only include two male participants. This makes it hard to apply the results to the general population. Future studies should include a larger group with both men and women.

For people with eye conditions like those in this study, it's important to practice yoga under a healthcare provider's supervision. Some yoga poses, especially inversions, can affect eye pressure, so it's important to get medical approval before starting. A doctor can also help adjust the practice to individual eye health needs.

The 8-week intervention showed some positive effects, but we don't know if these effects will last. Future research should include longer follow-up periods to check if the results are sustainable.

The study didn't track nutrition, which could have affected the results. While a neurologist-controlled medication, it wasn't the same for everyone, which might have caused differences in the results.

The participants were of different ages, which could have affected the outcomes. Also, inflammatory cytokines weren't measured, which could have been an important factor.

Future studies should address these limitations by tracking nutrition, standardizing medication, and accounting for age differences. It would also be useful to look at inflammatory markers.

It may also be valuable to combine drug therapy with low-intensity exercise and explore brain stimulation techniques like TMS or tDCS.

Finally, studying gender differences in the side effects of optic neuritis (ON) would be helpful, as this is a gap in current research.

What is already known on this subject?

COVID-19 vaccination has been associated with rare side effects, including optic neuritis (ON), typically managed through pharmacological interventions. While yoga therapy has demonstrated benefits in various health conditions, its role in the management of ON, particularly post-vaccination, remains underexplored.

What does this study add?

This study provides evidence that 8 weeks of yoga therapy led to significant improvements in visual function, physical performance, and quality of life in patients with COVID-19 vaccine-associated optic neuritis. The findings suggest that yoga therapy may serve as a complementary non-pharmacological approach to enhance recovery and support pharmacological treatments in managing vaccine-related optic neuritis.

Organ Cross-Talk Tips:

- Yoga enhances blood circulation, which can indirectly support eye health by ensuring that the eyes receive adequate oxygen and nutrients.

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Compliance with ethical standards

Conflict of interest The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest upon submitting this article.

Ethical approval The ethics code for this project, IR.MODARES.REC.1400.353, was approved by the Research Institute of Physical Education and Sports Sciences (Research Ethics Committee).

Informed consent Informed consent was obtained from all subjects involved in the study.

Author contributions

Conceptualization: E.A., S.Sh.; Methodology: E.A., S.Sh.; Software: E.A., S.Sh.; Validation: E.A., S.Sh., Formal analysis: E.A., S.Sh.; Investigation: E.A., S.Sh.; Resources: E.A., S.Sh.; Data curation: E.A., S.Sh.; Writing - original draft: E.A., S.Sh.; Writing – review & editing: E.A., S.Sh.; Visualization: E.A., S.Sh.; Supervision: S.Sh. Project administration: E.A., S.Sh.; Funding acquisition: S.Sh.

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