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Original Article

Hyperbaric Oxygen Therapy on Elderly's Sleep Quality: A Pre-Experimental Study

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Abstract

Background & Aim: The aging process makes the sleep quality of older people tend to decrease and affects sleep and rest patterns in the elderly population. Hyperbaric oxygen therapy is widely used to support clinical treatment. However, its use to address sleeping quality in the Indonesian elderly population is barely studied. This study aimed to determine the effects of hyperbaric oxygen therapy on the elderly's sleep quality. **Methods:** The study used a pre-experimental design. The intervention variable was ten sessions of hyperbaric oxygen therapy (HBOT), while the outcome variable was the sleep quality in the elderly. The sample was 65 persons, selected by simple random sampling from the eligible elderly patients receiving hyperbaric oxygen therapy at Naval Health Institute, Surabaya, Indonesia. The Pittsburgh Sleep Quality Index (PSQI) was used to assess the outcome and the data were analyzed with the Paired T-Test. **Results:** After receiving the HBOT, the average value of sleep quality in the elderly improved from 6.63 (poor category) to 4.35 (good category) with $p = 0.001$. The results indicate that HBOT could significantly improve sleep quality in the Indonesian elderly. **Conclusions:** HBOT can be used to treat elderly patients with sleep disorders. Further studies are needed to identify the long-term effect of HBOT on the outcome. Also, the provision of HBOT to improve sleep quality for the wider elderly population requires further investigation with a more rigorous methodology such as a randomized controlled trial.

Keywords: Elderly, Hyperbaric Oxygen Therapy, Sleep Quality

Introduction

Rest and sleep are basic needs that must be met by everyone (Hidayat, Kusnanto & Hannan 2021). When compared to other general health issues, poor sleep quality in the elderly is frequently overlooked (Gehrman & Ancoli-Israel, 2016). The elderly tend to experience a decrease in the quality of rest and sleep due to the aging process (Bu *et al.*, 2024). Insomnia is one of the most common sleep disorders in the elderly characterized by complaints of difficulty sleeping or maintaining sleep. There are some approaches that have been studied to improve sleep quality among the elderly in Indonesia that shows promising results, among others, sleep hygiene, brain gyms (Nursalam *et al.*, 2018), slow stroke back massages (Suarilah, Hayat & Indarwati, 2020), audio-visual stimulation (Sugianto *et al.*, 2017), and afternoon sunbath (Abidin, Harmayetty & Yasmara, 2019). Nevertheless, the use of Hyperbaric Oxygen Therapy (HBOT) to solve sleep disorders among the Indonesian elderly was barely explored.

HBOT is a therapy that provides 100% oxygen concentration in a pressurized room with more than 1 atmosphere absolute (ATA) (Rusoke-Dierich, 2018). With an increase in oxygen concentration due to gas solubility under pressure, the diffuse gradient is strengthened, allowing tissues to penetrate the cells (Shapira *et al.*, 2021). This is why hyperbaric oxygenation treatment improves tissue perfusion, hypoxia, ischemia, infarction, or poor necrotism (Gehrman & Ancoli-Israel, 2016). This therapy promotes tissue recovery while also facilitating reperfusion and angiogenesis (Rosyanti *et al.*, 2019).

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The effectiveness of HBOT in pathologies involving hypoperfusion, infection, ischemia, or infarction processes (Rusoke-Dierich, 2018), this hyperbaric oxygen therapy, if done properly and appropriately, can help patients recover faster, have fewer side effects or symptoms (Oley *et al.*, 2021), and this will directly affect function, socialization, productivity, and patient quality of life (Oley *et al.*, 2021).

⁹ In a study of 6,800 elderly patients over 65 years, it was discovered that 93% have one or more comorbid conditions and other factors, the most common of which are depression, chronic pain, cancer, chronic obstructive pulmonary disease, cardiovascular disease, medication use, and factors associated with aging, namely retirement, inactivity, or caregiver (González-Castro *et al.*, 2018). Most insomnia symptoms in the elderly may be explained by the increased prevalence of chronic conditions in later life; 1% to 7% of insomnia in later life occurs independently of chronic conditions (Vitiello, Moe & Prinz, 2002). In Indonesia, insomnia affects approximately 50% of people over the age of 65. Each year, it is estimated that approximately 20% – 50% of the elderly report insomnia, with approximately 17% experiencing severe insomnia. Insomnia affects approximately 67 percent of the elderly population (Gehrman & Ancoli-Israel, 2016).

The elderly typically experience a decrease in the quality of rest and sleep as a result of the aging process, which has an impact on changes in sleep and rest patterns (Gehrman & Ancoli-Israel, 2016). HBOT is widely used to supplement clinical treatment, where HBOT is beneficial in a variety of disease cases (Gehmert *et al.*, 2011). However, there has been no research on the effectiveness of HBOT on the need for sleep rest in the elderly up to this point. This study aimed to examine the effectiveness of HBOT on the sleep quality of the elderly.

Materials and Methods

The study used a pre-experimental research design with one group pre-test and post-test. The participants were elderly patients undergoing hyperbaric oxygen therapy at Naval Health Institute (LAKESLA) Drs. Med. R. Rijadi Sastropanoelar, Phys. Surabaya, Indonesia.

³ The population is all elderly who underwent hyperbaric oxygen therapy at LAKESLA Drs. Med. Rijadi Sastropanoelar, Phys. Surabaya Indonesia. Respondents are elderly who are taking hyperbaric oxygen therapy for the first time, with an age range of 45 to 70 years, cooperative respondents and not receiving anti-depressant drug therapy that helps patients sleep and not experience pain.

A sample of 65 respondents was selected through simple random sampling from patients who met the inclusion criteria, which were patients who had recently undergone HBO there Respondents over the age of 45, cooperative, did not experience pain, and were not receiving antidepressant therapy or sleeping pills. Patients who did not complete anti-depressant therapy for a variety of reasons were excluded from the study.

¹¹ Hyperbaric oxygen therapy is the administration of high-pressure oxygen for treatment carried out in a high-pressure air chamber. The patients spent 100% pure oxygen in a closed room with a pressure of 2.4 ATA for 3 × 30 minutes plus a rest period of 5 minutes each.

This study used a pre-experimental design. The intervention variable was ten sessions of hyperbaric oxygen therapy (HBOT), while the outcome variable was sleep quality in the elderly. A sample of 65 people, was selected by simple random sampling from the elderly who are eligible to receive hyperbaric oxygen therapy at the Navy Health Center, Surabaya, Indonesia. The assessment was carried out by researchers by interviewing respondents in several sessions and distributing questionnaires after the last therapy session. Pre-experimental data collection was carried out in January 2020 before the patient underwent HBO therapy and post-experimental data was completed in February 2020 after the patient underwent 10 HBO therapy.

The outcome variable was the elderly's sleep quality measured using the Indonesian version of the PSQI (Pittsburgh Sleep Quality Index) with Cronbach alpha of 0.63 (Vitiello, Moe & Prinz, 2002). The PSQI contains a sleep needs scale consisting of seven questions including subjective sleep needs, sleep latency, sleep duration, efficiency of sleep habits, sleep disturbance, use of sleeping pills, and

dysfunction during the day with a global score of 0 - 21. If the score is getting smaller then the quality of sleep is getting better. Sleep quality assessment was carried out before giving hyperbaric oxygen therapy intervention and after giving hyperbaric therapy intervention in the last week for one series (10 times therapy).

The collected data were tested for normality using the Kolmogorov-Smirnov analysis test, with a degree of significance > 0.05 , indicating that the data is normally distributed, and it can then be analyzed using the Paired T-test. This study has obtained ethical approval from the Health Research Ethics Committee of STIKES Hang Tuah Surabaya no. PE/56/XII/2020/KEPK/SHT.

Results

The demographic characteristics showed that 42 of the respondents (64.6%) were female, 31 (47.1%) were aged between 60 and 70 years, 30 (46.2%) had a monthly income of 2-3 million Indonesian rupiah (IDR), and 53 (81.5%) were not stressed. Thirty elderly (46.2%) had a history of diabetes mellitus, 54 (83.1%) did not smoke, and 61 (93.8%) did not consume alcohol. Regarding the activities, 23 (35.4%) of the elderly were still working, and 22 (33.8%) were caring for their grandchildren. Most elderly preferred to sleep in a dark room (38, 58.5%). Table 1 shows the demographic characteristics of the participants.

Table 2 shows that the average value of sleep quality in the elderly before HBOT was 6.63, indicating poor sleep quality, and 4.43 after 10 times HBOT, indicating good sleep quality. The Paired T-Test results showed that HBOT could significantly improve the elderly's sleep quality ($p = 0.001$).

Table 1: Demographic data of the respondents

Demographic Data	N	%
Gender		
Male	23	35.4
Female	42	64.6
Age		
45-59 Years	19	29.2
60-70 Years	31	47.7
< 70 Years	15	23.1
Monthly Income		
< 1 million	8	12.3
2-3 million	30	46.2
> 3 Million	27	41.5
Stress Condition		
Yes	12	18.5
No	53	81.5
Health History		
No disease	19	29.2
Diabetes Mellitus	30	46.2
Hypertension	4	6.2
Other Diseases	12	18.5
Smoking		
Yes	11	16.9
No	54	83.1
Alcoholic		
Yes	4	6.2
No	61	93.8
Main Activity		
Working	23	35.4
Relax	20	30.8
Take care of grandchildren	22	33.8
Habit Before Bedtime		
Bedroom Atmosphere		
Dark	38	58.5
Light	12	18.5
Dim	15	23.1

Table 2: The sleep quality measurement of the elderly before and after the HBOT

HBOT	Mean ± SD	p-value
Before	6.63 ± 1.409	0.001
After	4.43 ± 1.425	

Discussion

Based on the results of the study, it was found that the average need for rest and sleep in the elderly before doing HBO therapy at Lakesla Drs. Med. R. Rijadi S., Phys is 6.63 which means that the sleep quality of the elderly is in poor category. There are three models of factor that influence rest and sleep: predisposing, precipitating, and perpetuating factors. The predisposing factors: demographic, biologic, psychological, and social characteristic. The precipitating factors generally include stressful life events or medical conditions that may disrupt sleep. The perpetuating factors often consist of behavioral or cognitive changes that arise as a result of acute insomnia (Gehrman & Ancoli-Israel, 2016). A number of factors affect the need for rest and sleep in the elderly, namely physiological (age, gender, illness, activity, lifestyle), psychological (emotional stress, anxiety) and environmental factors (noise, temperature, ventilation, lighting) can change the need for rest and sleep (Sukmawati & Putra, 2019).

One of the factors that influence the need for rest and sleep is gender. Based on Table 1, the need for sleep rest before doing HBO therapy with data on the gender of the respondents, it was found that most of the respondents were female, there were 11 respondents (64.6%) and male respondents as many as 6 people (35.4%). Female are at a higher risk of experiencing bad rest and sleep than man.

Increasing a person's age will have an impact on disturbances in meeting basic human needs, one of which is the need for rest and sleep. Based on the results of the need for rest and sleep before doing HBO therapy with the age of the respondents, it was found that most of the respondents were 60-70 years old. Women older than 45 years are 1.7 times more likely to have insomnia than men (Morin *et al.*, 2006). Age has an influence on a person's need for rest and sleep which is associated with natural diseases and poor health (Shapira *et al.*, 2021).

Women who have menopause have low estrogen levels, in this condition, they often report excessive fatigue, sleep disturbances due to discomfort due to hot flashes, or night sweats which can occur due to decreased estrogen levels. The elderly usually have a sleep pattern of 20-30% REM sleep, sleeping more than six hours a day, in stage IV there is a lot less or sometimes none. The natural shortening of their total sleep time in some elderly may generate unrealistic expectations about sleep duration, producing anxiety that could cause or worsen rest and sleep (Bu *et al.*, 2024). Menopausal women usually have low estrogen levels. Women with low estrogen levels usually feel excessively tired. In addition, sleep disturbances can occur, as a result of feeling hot, and an increase in body temperature at night which can lead to a reduction in stages III and IV of NREM and REM sleep (Castro *et al.*, 2009).

The decrease in the hormones progesterone and estrogen which have receptors in the hypothalamus, is a direct contribution to circadian rhythm and sleep patterns. Psychological conditions in the form of increased anxiety, anxiety and emotions that are often uncontrolled in women are caused by a decrease in the hormone estrogen during menopause, which can cause sleep disturbances (Foley *et al.*, 2004).

Table 2, shows the average value of sleep quality in the elderly after HBOT is lower than before. HBOT greatly affects the need for rest and sleep in the elderly. Many of the functions of cells and body tissues depend on oxygen, thereby increasing the ability of cells and tissues to divide or regenerate, kill germs, and increase metabolism in cells which will produce many benefits for the body, one of which is increasing the effectiveness of the need for rest and sleep in the elderly (Shi *et al.*, 2024). Therapy by providing 100% oxygen in a pressure chamber of 2.4 ATA where oxygen will have flowed to areas that erythrocytes cannot reach and can cause tissue oxygenation even without oxygen transport with haemoglobin (Bin-Alamer *et al.*, 2024). The physiological effects of HBOT can be explained by the mechanism of oxygen dissolving in plasma. This therapy can increase the number of oxygen molecules that enter the body through breathing or pores or external tissues. With the increase in the oxygen

inhaled when the body is given a pressure of 2.4 ATA, the amount of dissolved oxygen in the blood increases. Oxygen is transported by the blood to all cells and tissues of the body. When hyperbaric oxygen therapy is administered at a pressure of more than 1 ATA (2.4 ATA), the concentration of oxygen in the blood plasma is 0.3 mL/dL. In a resting state, the tissue will take up oxygen 5-6 mL/dl of blood in normal perfusion. Administration of 100% oxygen under normobaric pressure will increase the dissolved oxygen in the blood by up to 1.5 mL/dl. When given a pressure of 3 atm, the dissolved oxygen will be approximately 6 mL/dL so that it will be more than sufficient to meet the needs of cells without requiring the involvement of haemoglobin. At a pressure of 2 ATA the pressure of oxygen in the blood increases 10 times. In the presence of dissolved oxygen, oxygen will flow to areas not reached by erythrocytes and can cause tissue oxygenation even though there is no transport of haemoglobin with oxygen (Gottfried, Schottlender & Ashery, 2021).

Sleep disorders are characterized by increased cortisol levels, changes in norepinephrine (NE), and malfunctions in the Hypothalamic-Pituitary-Adrenal (HPA) axis. Excessive HPA axis activity adversely impacts sleep, leading to irregular sleep patterns, decreased slow wave sleep, and shorter sleep duration. Elderly people who experience stress tend to trigger activation of the HPA axis through the hypothalamus, which causes the release of Corticotropin-Releasing Hormone (CRH). Then stimulates the production of adrenocorticotrophic hormone (ACTH), activating the adrenal glands to release cortisol, especially in situations involving increased levels of proinflammatory molecules such as interleukin-1 (IL-1), IL-6, and tumor necrosis factor- α (TNF- α), commonly observed in inflammatory conditions. This spike in cortisol levels contributes significantly to sleep disorders. Sleep problems may also involve increased nervous system metabolism to maintain neural electrical potential, demanding large oxygen consumption and resulting in significant oxidative production (Hisnindarsyah & Nandaka, 2023). In previous research, it was noted that cortisol levels decreased significantly ($p = 0.001$) after undergoing hyperbaric oxygen therapy (HBOT), which involved inhaling 100% oxygen for 60 minutes at 2.5ATA (Lund *et al.*, 1999). However, the mechanism behind this effect is not elucidated.

From the results of interviews with respondents, some respondents said there had been a change in the need for rest and sleep with 5 times therapy. Overall sleep quality was better, such as falling asleep and feeling refreshed after waking up. To fall asleep at night does not require a long time (<30 minutes). Some of the respondents even said that after the HBOT when they got home, they fell asleep immediately because their bodies felt refreshed. In patients who have a history of diabetes mellitus before doing therapy, they have to go to the bathroom at least 6 times a night, this will greatly disturb the need for sleep rest in the elderly, but after 5 therapies, patients only go to the bathroom 3-4 times to urinate. This occurs because one of the physiological effects of HBOT is to increase the sensitivity of insulin cells, thereby improving body regulation to regulate blood sugar levels (Untari *et al.*, 2021). Insulin helps store blood sugar so that blood sugar, does not become high, thereby lowering the oncotic blood pressure of people with diabetes and one of the effects is decreasing diuretic flow in the kidneys (Sedu *et al.*, 2020). With HBOT, it will reduce blood sugar levels through the mechanism of increasing the production of HSP 70 and decreasing the secretion of TNF- α will improve insulin receptors, then glucose enters the body tissues (skeletal, adipose cells and hepatocytes) so that blood sugar levels fall optimally, this has an impact in reducing free radicals, reducing complications of Diabetes Mellitus and increasing ATP synthesis in the body (Huchim, Rivas-sosa & Méndez-domínguez, 2017).

The limitation of this research is that there is no measurement of diseases that affect the need for rest and sleep quality.

Conclusion

The result showed hyperbaric oxygen therapy has an effect on rest and sleep quality of the elderly. The hyperbaric oxygen therapy therapy was effective in improving the need for rest and sleep in the elderly. Hyperbaric oxygen therapy has not been fully explored, including how long hyperbaric oxygen therapy must be taken so that the rest and sleep quality of the elderly is maintained.

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Conflict of Interest

The authors declare no conflict of interest regarding the publication of this paper.

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