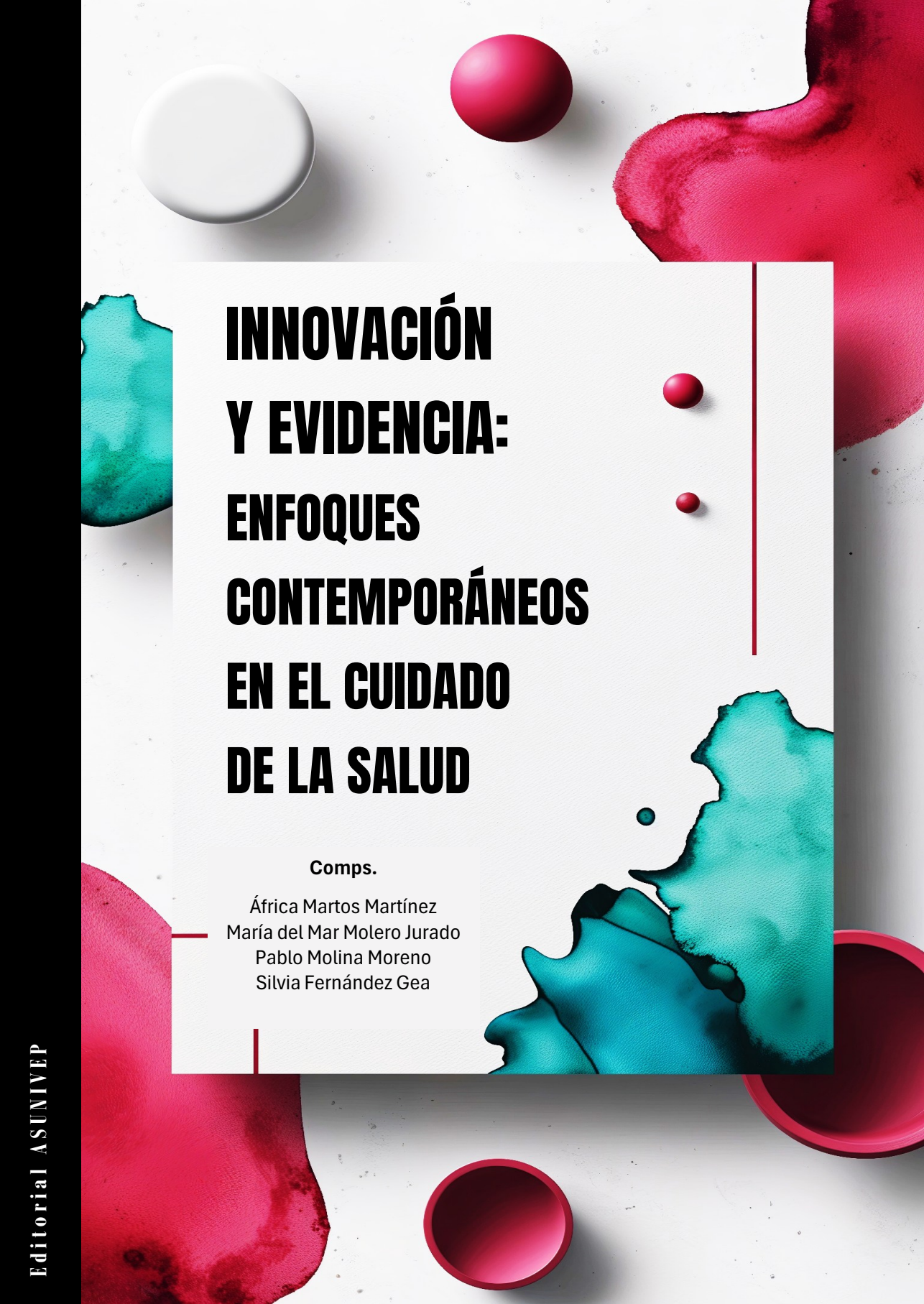




INNOVACIÓN Y EVIDENCIA: ENFOQUES CONTEMPORÁNEOS EN EL CUIDADO DE LA SALUD

Comps.

África Martos Martínez
María del Mar Molero Jurado
Pablo Molina Moreno
Silvia Fernández Gea

Innovación y evidencia: Enfoques contemporáneos en el cuidado de la salud

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Clinical and therapeutic factors associated with the response to hyperbaric recompression in decompression sickness: A systematic review

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Introduction

Decompression sickness (DCS) is a disorder resulting from a reduction in ambient pressure, primarily associated with scuba diving and other hyperbaric exposures. Its pathophysiology is related to the formation of inert gas bubbles within tissues and the vascular system during decompression, triggering mechanical, vascular, and inflammatory alterations of varying severity (Moon & Mitchell, 2021).

The clinical presentation of DCS is highly heterogeneous and depends on the location of the gas bubbles and the tissues involved. Clinical manifestations range from musculoskeletal and cutaneous symptoms to neurological, vestibular, and cardiorespiratory disorders. Central nervous system involvement represents one of the most severe forms of the disease because of its potential to cause permanent functional deficits (Durán Fernández et al., 2019; Moon & Mitchell, 2021).

Traditionally, DCS has been classified into Type I, characterized predominantly by musculoskeletal and cutaneous manifestations, and Type II, which involves neurological, vestibular, or cardiorespiratory impairment. However, the clinical presentation and subsequent course of DCS can vary considerably, particularly in cases involving the central nervous system (Moon & Mitchell, 2021).

Hyperbaric oxygen recompression therapy is the standard treatment for DCS. Its therapeutic effect combines mechanical reduction of bubble volume through increased ambient pressure with elevated oxygen partial pressure, thereby promoting inert gas elimination, improving tissue oxygenation, and reducing hypoxia (Bennett et al., 2010; Moon & Mitchell, 2021). Among the available treatment protocols, the US Navy Treatment Table 6 (USN TT6) is the most widely used. Nevertheless, variations remain regarding treatment pressure, duration, and breathing gas mixtures, and current evidence does not conclusively demonstrate the superiority of any single protocol (Bennett et al., 2010; Clarke, 2020; Moon & Mitchell, 2021).

Clinical response following recompression therapy is variable, suggesting that outcome may be influenced by both patient-related and treatment-related characteristics. Identifying the factors associated with therapeutic response is therefore clinically relevant for prognostic assessment and treatment decision-making.

The timing of recompression represents an important consideration in the management of DCS. Early recompression remains the recommended therapeutic approach; however, uncertainty persists regarding the extent to which treatment delay independently determines subsequent clinical outcome (Bennett et al., 2010; Moon & Mitchell, 2021).

Similarly, the heterogeneity of DCS presentation raises questions regarding the prognostic relevance of initial clinical status and other patient-related characteristics. A better understanding of these factors may help identify patients at greater risk of incomplete recovery or persistent neurological deficits.

The heterogeneity of both hyperbaric treatment protocols and the prognostic factors evaluated across studies makes it difficult to establish definitive recommendations regarding the main determinants of clinical outcome. Consequently, integrating the available evidence is essential to identify the clinical and therapeutic factors associated with a more favorable response to treatment.

Against this background, the present systematic review aims to evaluate the available scientific evidence on the clinical and therapeutic factors associated with the response to hyperbaric recompression therapy in patients with decompression sickness, with particular emphasis on initial clinical severity, time to recompression, characteristics of recompression protocols, and factors associated with recovery and the persistence of residual deficits.

Hypothesis

The clinical response to hyperbaric recompression therapy in patients with decompression sickness is influenced by both the initial severity and clinical presentation of the condition and the characteristics of the treatment received. In particular, initial clinical severity, symptom progression before recompression, time to treatment, and the hyperbaric treatment protocol may influence recovery and the persistence of residual deficits.

Aim

To analyze the clinical and therapeutic factors associated with the response to hyperbaric recompression therapy in patients with decompression sickness.

Specific objectives

- To identify the main clinical factors associated with the clinical outcome of patients with decompression sickness.
- To analyze the influence of time to recompression on clinical outcomes.
- To examine the relationship between different recompression protocols and therapeutic response.
- To evaluate the influence of initial clinical severity on subsequent clinical outcome.
- To describe the factors associated with incomplete recovery and the persistence of residual deficits following hyperbaric recompression therapy.

Methodology

Study design

A systematic review of the scientific literature was conducted to identify and analyze the clinical and therapeutic factors associated with the response to hyperbaric recompression therapy in patients with decompression sickness. The identification, selection, and reporting of studies followed the recommendations of the PRISMA 2020 Statement (Page et al., 2021).

The research question was: Which clinical and therapeutic factors are associated with the response to hyperbaric recompression therapy in patients with decompression sickness?

The review was structured around three components: the study population (patients with decompression sickness treated with hyperbaric recompression therapy), the clinical and therapeutic factors of interest, and the clinical outcomes, defined as complete recovery, persistent symptoms, or residual deficits following treatment.

Information sources and search strategy

Relevant studies were identified through a targeted literature search focusing on decompression sickness, hyperbaric recompression therapy, and prognostic factors. This search was complemented by manual screening of the reference lists of the selected articles to identify additional eligible studies.

The search strategy combined the terms Decompression Sickness, Decompression Illness, Spinal Cord Decompression Sickness, Hyperbaric Oxygen Therapy, Recompression, Treatment Outcome, Prognostic Factors, Delayed Recompression, and Risk Factors, using the Boolean operators AND and OR. The general search strategy was as follows: ("Decompression Sickness" OR "Decompression Illness" OR

"Spinal Cord Decompression Sickness") AND ("Hyperbaric Oxygen Therapy" OR "Recompression") AND ("Treatment Outcome" OR "Prognostic Factors" OR "Delayed Recompression" OR "Risk Factors").

Inclusion and exclusion criteria

Original studies involving human participants diagnosed with decompression sickness and treated with recompression or hyperbaric oxygen therapy were included if they evaluated clinical or therapeutic factors associated with patient outcomes and reported post-treatment clinical results.

Eligible study designs included retrospective and prospective observational studies, as well as investigations focusing on neurological or spinal cord decompression sickness. Studies using the broader term decompression illness were also considered when their populations and outcomes were relevant to the objectives of this review.

Narrative reviews, systematic reviews, meta-analyses, study protocols without clinical results, animal studies, publications addressing conditions other than decompression sickness, and studies that did not report clinical outcomes following recompression therapy were excluded.

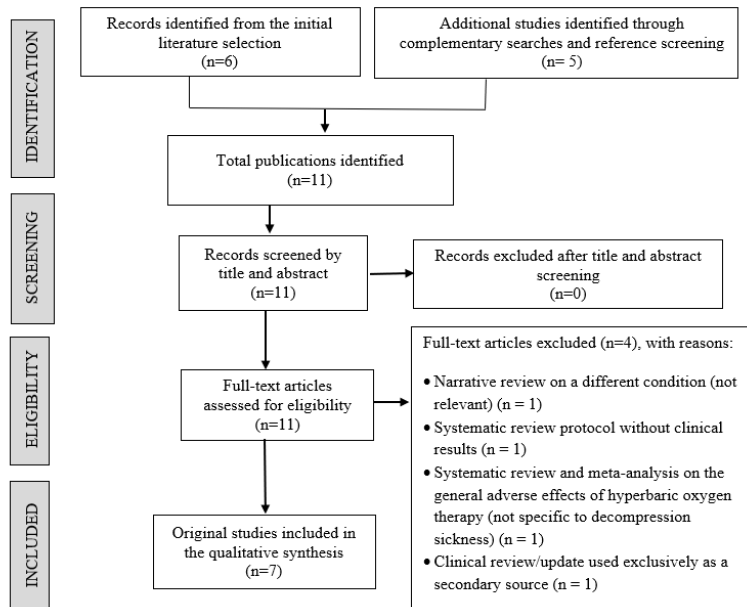
Study selection

Following the literature search and reference screening, 11 potentially relevant publications were identified. After applying the predefined eligibility criteria, four studies were excluded because they consisted of a narrative review addressing a different condition, a systematic review protocol without clinical results, a systematic review on the general adverse effects of hyperbaric oxygen therapy, and a clinical review used solely as a secondary source.

Ultimately, seven original studies were included in the qualitative synthesis. A potential partial overlap between the study populations of two publications was identified and considered during data interpretation to avoid duplication of findings.

The study identification, screening, eligibility assessment, and inclusion process is summarized in Figure 1, which was developed according to the PRISMA 2020 flow diagram (Page et al., 2021).

Figure 1. Flow diagram of the study selection process, developed according to the PRISMA 2020 framework



Data extraction and synthesis

The main methodological and clinical characteristics were extracted from each included study, including the author, year of publication, country, study design, sample size, characteristics of decompression sickness, hyperbaric treatment, clinical and therapeutic factors evaluated, outcome measures, and principal findings.

The extracted data were organized into a summary table to facilitate comparison across studies. The findings were subsequently grouped according to the main factors associated with clinical outcome, including initial clinical severity and presentation, symptom progression, time to recompression, characteristics of the hyperbaric treatment protocol, and other prognostic factors. When a potential overlap between study populations was identified, the studies were analyzed independently, and their sample sizes were not combined.

Methodological quality assessment

The methodological quality of the included studies was assessed using the critical appraisal tools developed by the Joanna Briggs Institute (JBI), selected according to the design of each study. The JBI Critical Appraisal Checklist for Cohort Studies was applied to cohort studies (Barker et al., 2025), whereas the JBI Critical Appraisal Checklist for Case Series was used to evaluate the case series (Munn et al., 2020).

The assessment considered participant selection, measurement of exposures and outcomes, control of potential confounding factors, adequacy of follow-up, and the appropriateness of the statistical analyses. For the case series, additional criteria included the consecutive inclusion of participants and the adequacy of the clinical description of the cases. Each appraisal domain was rated as "Yes," "No," "Unclear," or "Not Applicable," and an overall qualitative assessment was performed for each study.

Synthesis of the results

Due to the heterogeneity of the study populations, recompression protocols, prognostic factors evaluated, and clinical outcomes, a meta-analysis was not feasible. Therefore, the findings were integrated through a narrative synthesis, organized according to the main clinical and therapeutic factors associated with treatment response.

Results

Study selection and general characteristics

Following the application of the eligibility criteria, seven original studies published between 2010 and 2023 were included in the qualitative synthesis (Gempp & Blatteau, 2010; Blatteau et al., 2011; Hadanny et al., 2015; Chung & Ahn, 2017; Andre et al., 2022; Sokolowski et al., 2022; Simonnet et al., 2023). Most studies had a retrospective observational design, and their study populations consisted primarily of divers with decompression sickness, particularly those presenting with neurological or spinal cord involvement.

The included studies showed considerable heterogeneity in sample size, clinical severity, recompression protocols, and the prognostic factors evaluated. The most frequently investigated variables included initial clinical severity, time to recompression, symptom progression, age, diving characteristics, bladder dysfunction, magnetic resonance imaging (MRI) findings, and the hyperbaric treatment protocol. The main characteristics and findings of the included studies are summarized in Table 1.

A potential partial overlap was identified between the cohorts reported by Gempp and Blatteau (2010) and Blatteau et al. (2011); therefore, these populations were not considered cumulative during data interpretation. In addition, Sokolowski et al. (2022) included patients defined according to the broader concept of decompression illness, a factor that was taken into account when interpreting the findings.

Table 1. Main characteristics and findings of the studies included in the systematic review

Study	Design and sample	Population	Main factors analyzed	Primary outcome	Relevant findings
Gempp & Blatteau (2010)	Retrospective; n = 63	Spinal cord DCS	Initial severity, time to recompression, and treatment protocol	Recovery at 1 month	Initial clinical severity was the main independent predictor of incomplete recovery.
Blatteau et al. (2011)	Retrospective, multicenter; n = 279	Spinal cord DCS	Age, diving depth, bladder dysfunction, severity, clinical progression, treatment delay, and protocol	Sequelae at 1 month	Older age, diving depth, bladder dysfunction, greater severity, and unfavorable clinical progression were associated with a poorer prognosis.
Hadanny et al. (2015)	Retrospective; n = 204	DCS treated with early or delayed recompression	Time to recompression and treatment protocol	Complete, partial, or no recovery	No significant differences were observed between early and delayed recompression; the US Navy Treatment Table 6 was associated with more favorable outcomes.
Chung & Ahn (2017)	Retrospective; n = 12	Spinal cord DCS	Clinical manifestations and MRI findings	Neurological outcome	A normal initial MRI was associated with a favorable outcome, whereas extensive spinal cord lesions were more frequent among patients with sequelae.
Andre et al. (2022)	Retrospective; n = 195	Spinal cord DCS	Initial severity, prehospital oxygen, evacuation, and time to recompression	Neurological recovery at discharge	Greater initial severity and a time to recompression exceeding 194 minutes were associated with incomplete recovery.
Sokolowski et al. (2022)	Retrospective; n = 546	Decompression illness (DCI)	Treatment delay, severity, clinical symptoms, age, and initial treatment	Residual symptoms after HBOT	Delayed recompression retained therapeutic potential; greater clinical severity was associated with poorer outcomes.
Simonnet et al. (2023)	Retrospective; n = 102	Severe spinal cord DCS	Initial severity, early clinical progression, treatment delay, and recompression protocol	Neurological recovery	Initial severity and deterioration during the first 24 hours were associated with poorer prognosis; protocols at 2.8 ATA showed favorable outcomes compared with higher-pressure strategies.

Note: DCS: decompression sickness; DCI: decompression illness; HBOT: hyperbaric oxygen therapy; MRI: magnetic resonance imaging; ATA: atmospheres absolute

Initial clinical severity and presentation

Initial clinical severity was the prognostic factor most consistently associated with clinical outcome. Gempp and Blatteau (2010) identified initial neurological severity as the main independent predictor of incomplete recovery. Blatteau et al. (2011) confirmed this association and additionally identified bladder dysfunction and clinical deterioration before treatment as factors associated with an unfavorable outcome.

Similar findings were reported by Simonnet et al. (2023), who observed that greater initial severity and clinical deterioration during the first 24 hours increased the likelihood of persistent neurological deficits. Likewise, Andre et al. (2022) identified initial clinical severity as a predictor of incomplete recovery.

Hadanny et al. (2015) found that greater clinical severity was associated with a shorter time to symptom onset (OR = 1.071; 95% CI: 1.010–1.135; $p = 0.021$), whereas variables such as age, sex, maximum diving depth, breathing gas mixture, and diving experience were not significantly associated with disease severity.

Overall, initial clinical severity and early neurological deterioration emerged as the most consistent prognostic factors.

Influence of time to recompression

The influence of time to recompression on clinical outcome showed heterogeneous results across the included studies.

Hadanny et al. (2015) found no significant differences between early (<48 hours) and delayed (≥ 48 hours) recompression, with complete recovery rates of 78% and 76%, respectively ($p = 0.955$). Likewise,

no significant differences were observed among patients with neurological decompression sickness or between those with Type I and Type II DCS.

In contrast, Andre et al. (2022) reported that a delay exceeding 194 minutes before recompression was associated with a higher probability of incomplete neurological recovery, particularly in patients with more severe initial presentations. Similarly, Sokolowski et al. (2022) suggested that delayed recompression retained therapeutic value, although shorter treatment delays were associated with a reduced need for additional recompression sessions.

Overall, the findings indicate that earlier recompression was associated with more favorable outcomes in some studies, although this association was not consistently observed across the available evidence. Prolonged treatment delay did not preclude clinical benefit from recompression.

Influence of the recompression protocol

The characteristics of the recompression protocol were also associated with clinical outcome in some of the included studies.

Hadanny et al. (2015) reported more favorable outcomes with the US Navy Treatment Table 6 (USN TT6) than with a 2 ATA protocol administered for 90 minutes. Although the initial comparison did not reach statistical significance, multivariable analysis identified the USN TT6 protocol as an independent predictor of favorable clinical outcome (OR = 4.274; 95% CI: 1.425–12.822; $p = 0.009$).

Simonnet et al. (2023) found that treatment protocols using 2.8 ATA were associated with a lower frequency of neurological sequelae than 4 ATA protocols. They also suggested a potential benefit of early heliox administration, whereas lidocaine did not appear to improve clinical outcomes.

Although these findings suggest an association between the recompression protocol and therapeutic response, they should be interpreted with caution given the observational design of the included studies.

Other potential prognostic factors

In addition to initial clinical severity, time to recompression, and treatment characteristics, the included studies identified other factors potentially associated with clinical outcome.

Blatteau et al. (2011) reported associations between persistent neurological sequelae and variables such as older age, specific diving characteristics, and the presence of bladder dysfunction. These factors were associated with an increased risk of an unfavorable outcome.

Chung and Ahn (2017) evaluated the prognostic value of magnetic resonance imaging (MRI) in patients with spinal cord decompression sickness. Patients with a normal initial MRI showed more favorable clinical outcomes, whereas more extensive spinal cord lesions were more frequently observed among those who developed persistent neurological deficits. However, the small sample size limits the generalizability of these findings.

Taken together, the findings address the predefined objectives of the review by identifying several clinical and therapeutic factors associated with the response to hyperbaric recompression therapy. Initial clinical severity and early neurological progression emerged as the most consistent prognostic factors, whereas the independent influence of time to recompression was less consistent across studies. Recompression protocol characteristics and additional factors, including age, diving characteristics, bladder dysfunction, and MRI findings, were also associated with clinical outcome or persistent neurological sequelae in some studies.

Methodological quality assessment

The methodological quality assessment, conducted using the Joanna Briggs Institute (JBI) critical appraisal tools, indicated an overall methodological quality ranging from moderate to moderate-high. Most studies clearly defined their study populations and clinical outcomes, and most cohort studies incorporated multivariable or adjusted analyses to account for potential confounding factors. In contrast, Sokolowski et

al. (2022) relied primarily on bivariate analyses, limiting the independent interpretation of the relationship between treatment delay, initial clinical severity, and outcome.

The study by Chung and Ahn (2017), assessed using the JBI Critical Appraisal Checklist for Case Series, provided an adequate clinical description but did not clearly report whether participants were enrolled consecutively and completely; it was also limited by its small sample size. The methodological assessment of Andre et al. (2022) should be interpreted with caution because the available methodological information was insufficient to verify all criteria of the corresponding JBI critical appraisal tool. The main findings of the methodological quality assessment are summarized in Table 2.

Table 2. Methodological quality assessment of the studies included in the systematic review

Study	JBI appraisal tool	Main methodological strengths	Main limitations	Overall assessment
Gempp & Blatteau (2010)	JBI Critical Appraisal Checklist for Cohort Studies	Clinically well-defined population; analysis of prognostic factors; use of multivariable analysis	Retrospective design; potential residual confounding; single-center study	Moderate-high
Blatteau et al. (2011)	JBI Critical Appraisal Checklist for Cohort Studies	Large multicenter sample; assessment of multiple prognostic factors; adjusted analysis	Retrospective design; variability in clinical management across centers; potential residual confounding	Moderate-high
Hadanny et al. (2015)	JBI Critical Appraisal Checklist for Cohort Studies	Comparison between treatment groups; well-characterized clinical variables; multivariable analysis	Retrospective design; lack of randomization; potential bias in treatment protocol selection	Moderate-high
Chung & Ahn (2017)	JBI Critical Appraisal Checklist for Case Series	Clinical and radiological description of patients; assessment of neurological outcome	Very small sample; retrospective design; limited generalizability,	Moderate
Andre et al. (2022)	JBI Critical Appraisal Checklist for Cohort Studies	Analysis of factors related to prehospital management and neurological outcome	Retrospective design; potential confounding between severity, treatment delay, and treatment; methodological information not fully available for verification	Moderate (provisional)
Sokolowski et al. (2022)	JBI Critical Appraisal Checklist for Cohort Studies	Large sample size; analysis of treatment delay and clinical outcomes	Retrospective design; clinical heterogeneity related to the broader concept of <i>decompression illness</i> ; potential residual confounding	Moderate-high
Simonnet et al. (2023)	JBI Critical Appraisal Checklist for Cohort Studies	Detailed characterization of severe cases; analysis of prognostic and therapeutic factors; assessment of neurological outcomes	Retrospective design; potential indication bias in the selection of treatment protocols	Moderate-high

Note: JBI: Joanna Briggs Institute. The overall assessment was based on a qualitative interpretation of the methodological domains corresponding to each appraisal tool rather than on the calculation of a numerical score. The categories used are descriptive and were established specifically for the purposes of the present review

Limitations and future directions

The findings of this systematic review should be interpreted in light of several limitations. First, the available evidence is derived predominantly from retrospective observational studies, which limits the ability to establish causal relationships and increases susceptibility to selection bias and residual confounding. The absence of comparative clinical trials is understandable given the ethical concerns associated with deliberately delaying or modifying a treatment considered the standard of care for decompression sickness.

Furthermore, substantial heterogeneity was observed across the included studies regarding patient severity and clinical presentation, recompression protocols, the definition of early versus delayed treatment, and the timing of outcome assessment. These differences limit the direct comparability of the findings and preclude definitive conclusions regarding specific therapeutic factors.

Additional limitations include the potential partial overlap between some study populations and the relatively small sample sizes of several investigations. Moreover, the inclusion of one study based on the broader concept of decompression illness introduced additional clinical heterogeneity.

Future research should adopt standardized definitions of disease severity, exposure characteristics, and clinical outcomes to facilitate more reliable comparisons across studies. Prospective multicenter studies and international registries may be particularly valuable for clarifying the independent influence of time to recompression and for comparing different recompression protocols. Furthermore, the development of prognostic models integrating initial clinical severity, early neurological progression, diving characteristics, time to treatment, and imaging findings would contribute to improving risk stratification and clinical decision-making.

Conclusions

The available evidence indicates that the clinical response to hyperbaric recompression therapy in decompression sickness is influenced by multiple factors and does not depend solely on the time elapsed before treatment. Initial clinical severity and early neurological progression emerged as the prognostic factors most consistently associated with the persistence of neurological sequelae.

Although early recompression remains the preferred therapeutic approach, several studies have reported favorable outcomes even when treatment was initiated after prolonged delays. Therefore, treatment delay alone should not be considered a reason to withhold recompression therapy.

The characteristics of the recompression protocol may also influence clinical outcomes. The available evidence suggests favorable results with standardized protocols such as the US Navy Treatment Table 6 (USN TT6) and does not consistently demonstrate additional benefit from the use of higher treatment pressures. However, these associations should be interpreted cautiously because treatment selection may have been influenced by the initial clinical severity of the patients.

Overall, prognostic assessment in patients with decompression sickness should integrate initial clinical presentation, early neurological progression, and treatment-related factors. The heterogeneity and predominantly retrospective nature of the available evidence highlight the need for well-designed prospective multicenter studies to better define the clinical and therapeutic factors that determine the response to hyperbaric recompression therapy.

References

- Andre, S., Lehot, H., Morin, J., Louge, P., de Maistre, S., Roffi, R., Druelle, A., Gemppe, E., Vallée, N., Vergne, M., & Blatteau, J.-E. (2022). Influence of prehospital management on the outcome of spinal cord decompression sickness in scuba divers. *Emergency Medicine Journal*, 39(10), 747–752. <https://doi.org/10.1136/emmermed-2021-211227>
- Barker, T. H., Hasanoff, S., Aromataris, E., Stone, J. C., Leonardi-Bee, J., Sears, K., Habibi, N., Klugar, M., Tufanaru, C., Moola, S., Liu, X. L., & Munn, Z. (2025). The revised JBI critical appraisal tool for the assessment of risk of bias for cohort studies. *JBIC Evidence Synthesis*, 23(3), 441–453. <https://doi.org/10.11124/JBIES-24-00103>
- Bennett, M. H., Lehm, J. P., Mitchell, S. J., & Wasiak, J. (2010). Recompression and adjunctive therapy for decompression illness: A systematic review of randomized controlled trials. *Anesthesia & Analgesia*, 111(3), 757–762. <https://doi.org/10.1213/ANE.0b013e3181c8b081>
- Blatteau, J.-E., Gemppe, E., Simon, O., Coulange, M., Delafosse, B., Souday, V., Cochard, G., Arvieux, J., Henckes, A., Lafère, P., Germonpré, P., Lapoussière, J.-M., Hugon, M., Constantin, P., & Barthélémy, A. (2011). Prognostic factors of spinal cord decompression sickness in recreational diving: Retrospective and multicentric analysis of 279 cases. *Neurocritical Care*, 15(1), 120–127. <https://doi.org/10.1007/s12028-010-9370-1>
- Chung, J. M. & Ahn, J. Y. (2017). Relationship between clinical and radiologic findings of spinal cord injury in decompression sickness. *Undersea & Hyperbaric Medicine*, 44(1), 57–62.
- Clarke, R. (2020). Monoplace chamber treatment of decompression illness: Review and commentary. *Diving and Hyperbaric Medicine*, 50(3), 264–272.
- Durán Fernández, S., Fonseca Sarmento, J., & Leyva Urquiza, F. (2019). Enfermedad descompresiva grave en buzo aficionado. *Revista Cubana de Medicina Militar*, 48(1), e197.
- Gemppe, E. & Blatteau, J.-E. (2010). Risk factors and treatment outcome in scuba divers with spinal cord decompression sickness. *Journal of Critical Care*, 25(2), 236–242. <https://doi.org/10.1016/j.jcrc.2009.05.011>

Hadanny, A., Fishlev, G., Bechor, Y., Bergan, J., Friedman, M., Maliar, A., & Efrati, S. (2015). Delayed recompression for decompression sickness: Retrospective analysis. *PLOS ONE*, 10(4), e0124919. <https://doi.org/10.1371/journal.pone.0124919>

Moon, R. E. & Mitchell, S. J. (2021). Hyperbaric oxygen treatment for decompression sickness: 2021 update. *Undersea & Hyperbaric Medicine*, 48(4), 421–435.

Munn, Z., Barker, T. H., Moola, S., Tufanaru, C., Stern, C., McArthur, A., Stephenson, M., & Aromataris, E. (2020). Methodological quality of case series studies: An introduction to the JBI critical appraisal tool. *JBI Evidence Synthesis*, 18(10), 2127–2133. <https://doi.org/10.11124/JBISRIR-D-19-00099>

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. <https://doi.org/10.1136/bmj.n71>

Simonnet, B., Roffi, R., Lehot, H., Morin, J., Druelle, A., Daubresse, L., & Blatteau, J.-E. (2023). Therapeutic management of severe spinal cord decompression sickness in a hyperbaric center. *Frontiers in Medicine*, 10, 1172646. <https://doi.org/10.3389/fmed.2023.1172646>

Sokolowski, S. A., Räisänen-Sokolowski, A. K., Tuominen, L. J., & Lundell, R. V. (2022). Delayed treatment for decompression illness: Factors associated with long treatment delays and treatment outcome. *Diving and Hyperbaric Medicine*, 52(4), 271–276. <https://doi.org/10.28920/dhm52.4.271-276>