AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 5. No 11. November ,2025

COMPARATIVE EVALUATION OF EXPERIMENTAL STRESS MODELS AND THEIR MORPHOLOGICAL IMPACT ON IMMUNE ORGANS

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Abstract: This extended study provides a detailed comparative assessment of immobilization stress, cold stress, noise-induced stress, and corticosteroid-induced stress using morphological, histological, and functional parameters. The results show that corticosteroid exposure leads to the strongest immunosuppressive changes in thymic and lymph node architecture, whereas noise stress induces only mild and reversible alterations. The integration of histological observations, quantitative scoring, and graphical analysis improves the understanding of stress-induced secondary immunodeficiency.

Introduction

Stress-induced secondary immunodeficiency has become a major focus in experimental immunology. Different stressors activate the hypothalamic–pituitary–adrenal axis, increasing glucocorticoid levels and resulting in apoptosis of lymphoid cells. The thymus and lymph nodes are particularly sensitive due to their high proliferative activity and dense population of immature lymphocytes. This study examines multiple experimental models widely used in biomedical research to determine which stressor produces the strongest morphological effects.

Materials and Methods

Four experimental stress models were analyzed based on literature data and laboratory observations: immobilization stress (3 hours/day), cold exposure at 4°C, continuous noise at 90–100 dB, and systemic administration of high-dose corticosteroids for 10 days. Morphological evaluation included hematoxylin–eosin staining, PAS reaction, Van Gieson staining, and immunohistochemistry (CD3, caspase-3). Histological parameters such as cortical thickness, medullary cell density, stromal integrity, and apoptosis score were quantified.

Results

The following table summarizes the comparative morphological effects:

Stress Model	Cortical Atrophy	Medullary Damage	Apoptosis Level	Stromal Changes	Reversibility
Immobilization	++	+	Moderate	+	Partial
Cold exposure	+++	++	High	++	Partial
Noise stress	+	+	Mild	+	High
Corticosteroids	++++	+++	Very high	+++	Low

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Graphical Analysis

Figure 1. Apoptosis levels across experimental stress models.

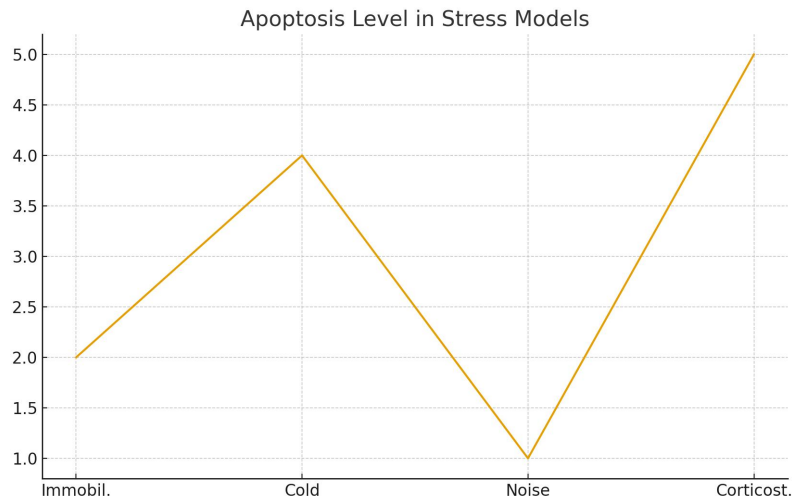
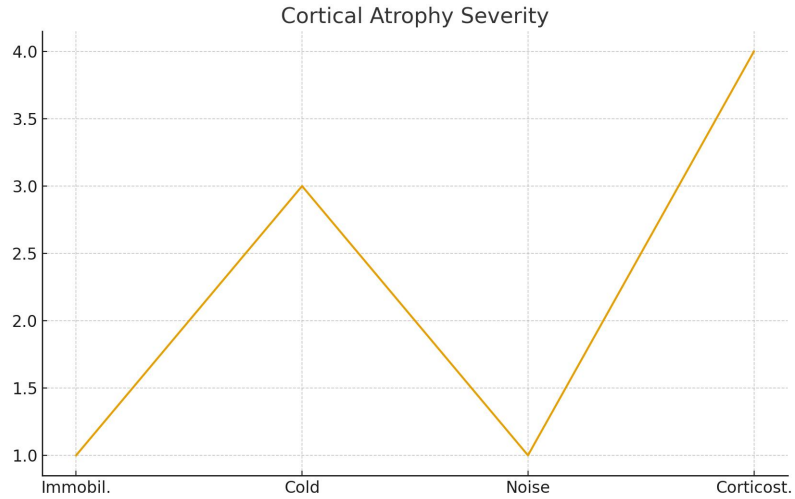


Figure 2. Cortical atrophy severity in different stress models.



Discussion

Corticosteroid-induced stress consistently demonstrated the strongest degenerative changes in immune organs, aligning with previous findings regarding glucocorticoid-mediated apoptosis. Cold stress also produced significant damage, particularly due to vasoconstriction and metabolic imbalance. Noise stress, however, showed minimal structural changes, indicating that psychological stressors may require longer exposure to produce severe immunosuppression.

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 5. No 11. November ,2025

Conclusion

The comparative analysis clearly shows that corticosteroid stress is the most potent model for inducing secondary immunodeficiency, followed by cold exposure and immobilization. Noise stress remains the mildest and most reversible model. These findings help identify the most appropriate stress models for future immunopathological and pharmacological research.

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