American Journal of Psychiatric Rehabilitation

Expert Opinion Article

EFFECT OF ACADEMIC EXAMINATION STRESS ON HAND GRIP STRENGTH AMONG FIRST-YEAR MEDICAL STUDENTS

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Abstract
Background: Examination stress is a predictable and recurrent stressor in medical education. While psychological consequences are well documented, its physiological effects on skeletal muscle function remain underexplored.
Objective: To assess the effect of examination stress on skeletal muscle function among first-year medical students using handgrip dynamometer.
Methods: A comparative cross-sectional study was conducted among 100 first-year MBBS students (18–23 years). Measurements were taken during pre-examination (stressed) and post-examination (relaxed) phases. Stress was assessed using the Perceived Stress Scale (PSS-10). Maximum Voluntary Contraction (MVC) and endurance time were recorded using hand grip dynamometer. Paired t-test/Wilcoxon signed-rank test was used for comparison.
Results: PSS scores were significantly higher during the pre-examination phase ($p < 0.001$). MVC and endurance time were significantly reduced during the stressed state compared to the relaxed state ($p < 0.05$).
Conclusion: Examination stress significantly reduces skeletal muscle strength and endurance. Early stress-management interventions may improve both psychological and physiological well-being among medical students.

Keywords: Examination stress, MVC, Handgrip dynamometer, Medical students, PSS

Introduction

Stress is an inevitable component of human life and represents a physiological and psychological response to internal or external demands that threaten homeostasis. Hans Selye defined stress as the "non-specific response of the body to any demand placed upon it," emphasizing that stress activates complex neuroendocrine mechanisms designed to promote adaptation and survival. While short-term stress may enhance alertness and performance (eustress), excessive or prolonged stress (distress) can lead to significant dysfunction across multiple organ systems.

In modern academic environments, especially in professional courses such as medicine, examination stress has emerged as one of the most predictable and recurrent stressors among young adults. Medical education is widely recognized as academically rigorous and emotionally demanding. Students are required to assimilate vast volumes of theoretical knowledge, develop clinical reasoning skills, participate in laboratory sessions and cadaveric dissections, and undergo frequent internal and university examinations. These cumulative academic pressures make medical students particularly vulnerable to stress-related disturbances.

The first year of MBBS training represents a critical transitional phase. Students must adapt to a new learning environment, structured schedules, competitive peer interactions, and high parental and societal expectations. Several Indian and international studies report elevated levels of perceived stress, anxiety, sleep disturbances, and emotional exhaustion among first-year medical students compared to their senior counterparts. Examination periods, in particular, act as acute stress triggers, activating physiological stress pathways that may influence multiple body systems, including the neuromuscular system.

Physiologically, stress activates two major systems:

1. **Hypothalamic–Pituitary–Adrenal (HPA) Axis** – leading to increased secretion of cortisol, a glucocorticoid hormone that promotes gluconeogenesis, protein catabolism, and suppression of muscle protein synthesis. Chronic elevation of cortisol can impair skeletal muscle integrity and reduce muscular strength.

2. **Sympathetic–Adrenal–Medullary (SAM) System** – resulting in the release of catecholamines (adrenaline and noradrenaline), which increase heart rate, blood pressure, and peripheral vasoconstriction. Sustained sympathetic activation may reduce muscle perfusion, accelerate lactate accumulation, and precipitate early muscle fatigue.

Skeletal muscle function depends on optimal neural drive, motor unit recruitment, adequate energy substrate availability, and efficient metabolic balance. Stress-induced hormonal and autonomic changes can disrupt neuromuscular transmission, impair motor coordination, decrease endurance capacity, and alter voluntary contraction strength. Although these changes may appear subtle, they can be objectively measured using validated physiological tools.

Handgrip dynamometry provides a reliable measure of Maximum Voluntary Contraction (MVC) and muscle endurance. It reflects overall neuromuscular efficiency and has been widely used in physiological and clinical research. It provides an objective and reproducible assessment of skeletal muscle performance.

While psychological aspects of examination stress have been extensively documented, relatively fewer studies have examined its direct physiological impact on skeletal muscle function, particularly among Indian medical students using dynamometry. Understanding these objective neuromuscular alterations is important because stress-related reductions in muscle performance may not only affect physical efficiency but may also reflect broader systemic stress responses.

Therefore, the present study aims to evaluate the effect of examination stress on skeletal muscle function among first-year medical students by comparing Maximum Voluntary Contraction, endurance time, and work done during stressed (pre-examination) and relaxed (post-examination) states. By integrating psychological assessment through the Perceived Stress Scale (PSS-10) with objective physiological measurements, this study seeks to provide comprehensive evidence linking academic stress with measurable neuromuscular outcomes.

The findings of this research may contribute to improved stress-management strategies, early identification of vulnerable students, and development of institutional wellness programs aimed at promoting both academic success and physiological well-being among medical trainees.

Objectives

1. To assess perceived stress using PSS-10.
2. To measure Maximum Voluntary Contraction (MVC).
3. To measure muscle endurance time.
4. To compare parameters between stressed and relaxed states.

Literature Review

1. Theoretical Background of Stress

Stress is a psychophysiological response that occurs when perceived demands exceed an individual's coping capacity. Hans Selye's General Adaptation Syndrome (GAS) explains stress progression through alarm, resistance, and exhaustion phases. Acute activation enhances survival, but prolonged exposure disrupts neuroendocrine balance, leading to systemic dysfunction.

Two principal biological pathways mediate the stress response:

- **Hypothalamic–Pituitary–Adrenal (HPA) Axis**
- **Sympathetic–Adrenal–Medullary (SAM) System**

Activation of the HPA axis increases cortisol secretion, promoting gluconeogenesis and protein catabolism. Sustained cortisol elevation contributes to skeletal muscle protein breakdown and reduced contractile efficiency. Simultaneously, SAM activation elevates catecholamines, causing peripheral vasoconstriction and altered neuromuscular transmission.

2. Academic and Examination Stress in Medical Students

Medical education is globally recognized as highly demanding. Academic overload, competitive environments, frequent assessments, and high parental expectations make medical students particularly susceptible to stress.

Research across India, Europe, and Asia consistently reports:

- Increased perceived stress scores during examinations
- Elevated salivary cortisol levels
- Reduced sleep duration
- Increased anxiety and depressive symptoms
- Autonomic imbalance (↑ HR, ↑ BP, ↓ HRV)

First-year MBBS students are especially vulnerable due to transition stress, curriculum adaptation, and new academic pressures.

Examination stress is cyclical and predictable, resulting in repeated activation of stress pathways, which may cumulatively affect physiological systems, including skeletal muscle function.

3. Physiological Impact of Stress on Skeletal Muscle

Stress influences skeletal muscle function through multiple mechanisms:

3.1 Hormonal Effects

Elevated cortisol:

- Increases muscle protein breakdown
- Suppresses protein synthesis
- Reduces muscle mass and strength
- Alters glucose utilization

3.2 Neural Effects

Excess sympathetic discharge:

- Alters motor unit recruitment
- Reduces neuromuscular precision
- Impairs fine motor control

3.3 Vascular Effects

Peripheral vasoconstriction:

- Reduces oxygen supply
- Accelerates lactate accumulation
- Promotes early fatigue

3.4 Metabolic Effects

Stress increases anaerobic metabolism, leading to:

- Increased lactate production
- Intracellular acidosis
- Reduced endurance capacity

These mechanisms collectively contribute to decreased Maximum Voluntary Contraction (MVC), shortened endurance time, and reduced work output.

4. Assessment of Skeletal Muscle Function

4.1 Handgrip Dynamometry

Handgrip strength is a validated indicator of overall neuromuscular performance. It reflects motor unit recruitment, muscle fiber integrity, and metabolic efficiency.

Studies show:

- Reduced grip strength during stress
- Correlation between stress levels and MVC decline
- Association between psychological distress and lower handgrip strength

It is highly sensitive to central fatigue and psychological influences. Stress-induced fatigue is reflected as a reduction in maximal grip force and diminished sustained contraction during dynamometric assessment.

5. Perceived Stress Scale (PSS) in Academic Research

The PSS-10, developed by Cohen (1983), is widely used to quantify perceived stress. It has strong internal consistency and correlates with physiological stress markers such as cortisol.

Medical student studies report:

- Moderate to high stress scores during examination periods
- Strong association between PSS scores and physiological changes

6. Empirical Studies on Stress and Muscle Function

Mantur et al. (2022)

Reported significant reduction in handgrip strength and work done during examination stress among medical students.

Barre et al. (2024)

Identified lower handgrip strength among highly stressed students; physical activity showed protective effects.

Paz-Cortés et al. (2024)

Observed altered muscle oxygen saturation and increased cortisol during high academic stress.

Poornima et al. (2014)

Found inverse correlation between perceived stress and Maximum Voluntary Contraction.

Ren et al. (2020)

Reported association between reduced handgrip strength and depressive symptoms.

Collectively, these studies demonstrate that stress affects not only psychological health but also objective neuromuscular performance.

7. Research Gap

Although psychological stress among medical students has been widely studied, limited Indian research has:

- Simultaneously evaluated MVC and endurance time.
- Compared pre- and post-examination states within the same participants
- Integrated subjective stress scores with objective neuromuscular measurement

Therefore, further research is warranted to objectively quantify stress-induced changes in skeletal muscle function among first-year medical students.

Stress Pathways

The human body responds to stress through two major physiological systems:

A. Hypothalamic–Pituitary–Adrenal (HPA) Axis

The Hypothalamic–Pituitary–Adrenal (HPA) axis is the main neuroendocrine system that controls how the body reacts to stress over time. When the brain perceives a stressor, higher brain centers like the amygdala tell the hypothalamus to release corticotropin-releasing hormone (CRH). This then tells the anterior pituitary to release adrenocorticotropic hormone (ACTH). ACTH moves through the blood to the adrenal cortex, where it helps make and release glucocorticoids, especially cortisol. Cortisol helps the body deal with stress by raising blood sugar levels through gluconeogenesis, speeding up protein breakdown, and speeding up lipolysis. This makes sure that there is always a steady supply of energy. Even while these reactions are necessary for short-term survival, keeping the HPA axis active for too long is bad. Long-term high levels of cortisol hurt muscle protein synthesis, speed up muscle breakdown, lower immunity, mess up sleep patterns, change cognition, and lower neuromuscular efficiency. This kind of long-term activation is prevalent in people who are under a lot of psychological stress, such medical students who are stressed about their studies and tests. This makes the HPA axis very important for understanding how stress affects skeletal muscle performance.

B. Sympathetic–Adrenal–Medullary (SAM) Axis

The Sympathetic–Adrenal–Medullary (SAM) system controls the body's quick "fight-or flight" reaction to stress. When a stressor is sensed, the sympathetic nervous system is quickly turned on. This causes sympathetic fibers to tell the adrenal medulla to release the catecholamines adrenaline (epinephrine) and noradrenaline (norepinephrine). These hormones cause a number of changes in the body, including as a faster heart rate and cardiac output, higher blood pressure, bronchodilation, and peripheral vasoconstriction. They also make you more alert and move blood away from the skin and internal organs and into the skeletal muscles to get the body ready for quick action. While these reactions are helpful during short-term stress, long-term sympathetic activation can hurt the musculoskeletal system by lowering muscle perfusion, speeding up the onset of tiredness, and making muscles less efficient while under long-term psychological stress.

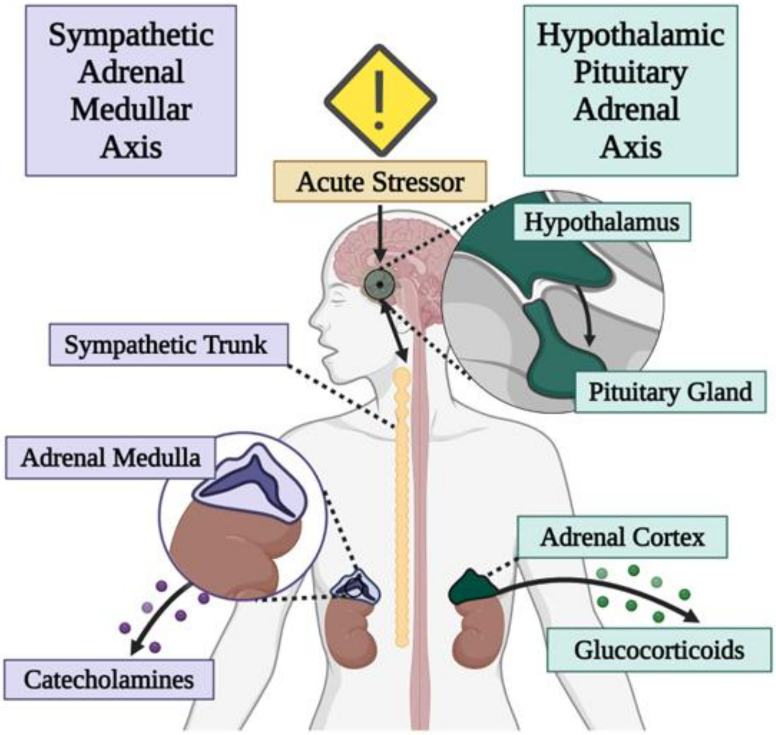

Figure 1: Stress pathways

Methodology

Study Design

The present study was conducted using an **observational, comparative, cross-sectional research design**. The study compared skeletal muscle function parameters during two physiological states within the same participants:

1. **Pre-examination phase (Stressed state)**
2. **Post-examination phase (Relaxed state)**

A **within-subject comparison model** was adopted, where each participant served as their own control. This approach minimized inter-individual variability and enhanced the accuracy of detecting stress-induced neuromuscular changes.

Study Setting

The study was carried out in the **Department of Physiology, ESIC Medical College & PGIMSR, Bengaluru**.

The department is equipped with:

- Handgrip dynamometer
- Anthropometric instruments
- Standardized physiology laboratory setup
  All measurements were conducted under controlled laboratory conditions following standard operating procedures.

Study Population

The study population comprised **first-year MBBS students** enrolled at ESIC Medical College & PGIMSR, Bengaluru, during the academic year and scheduled to appear for the final internal assessment examination.

First-year students were selected because they are considered more vulnerable to academic and examination stress due to:

- Transition into professional medical education
- Heavy syllabus
- Frequent assessments
- Academic adjustment challenges

Sample Size

Sample size: 100 students

- Approximately equal representation of males and females (50–55 each, depending on availability).

The sample size was considered adequate to detect statistically significant differences between stressed and relaxed phases.

Sampling Technique

A **simple random sampling method** was used.

Procedure:

1. The complete class list of eligible first-year MBBS students was obtained.
2. Each student was assigned a unique identification number.
3. A computer-generated random number method was used to select 100 participants.
4. If a selected participant met exclusion criteria or declined participation, the next randomly selected student was included.

This method ensured:

- Equal probability of selection
- Reduction of selection bias
- Improved internal validit

Inclusion Criteria

- First-year MBBS students
- Age between 18–23 years
- Clinically healthy individuals
- Students who provided written informed consent

Exclusion Criteria

- Students not willing to participate
- Students with any known muscular disorder
- Students medically unfit to perform muscle strength tests

Ethical Considerations

- Ethical clearance was obtained from the **Institutional Ethics Committee (IEC)** prior to study commencement.
- Written informed consent was obtained from all participants.
- Confidentiality was maintained using coded identification numbers.
- All procedures were non-invasive.
- Participants were free to withdraw at any time without academic consequences.

Study Variables

Independent Variable

Examination Stress

Measured at two time points:

1. Pre-examination (stressed state)
2. Post-examination (relaxed state)

Stress levels were assessed using the **Perceived Stress Scale (PSS-10).**

Dependent Variables

1. **Maximum Voluntary Contraction (MVC)** – measured in kilograms
2. **Muscle Endurance Time** – measured in seconds

Data Collection Procedure

Data collection was conducted systematically in two phases:

Phase 1: Pre-Examination (Stressed Phase)

Conducted one week before final internal examination during peak academic stress.

Phase 2: Post-Examination (Relaxed Phase)

Conducted one week after completion of examination when no imminent assessments were scheduled.

Assessment Procedures

1. Stress Assessment

The **Perceived Stress Scale (PSS-10)** was administered in a quiet environment during both phases.

Scoring classification:

- 0–13 → Low stress
- 14–26 → Moderate stress
- 27–40 → High stress

2. Muscle Strength Assessment

Handgrip Dynamometer

Procedure:

- Participant seated comfortably.
- Elbow flexed at 90°.
- Instrument explained and demonstrated.
- Two maximum-effort trials performed.
- One-minute rest between trials.
- Mean value recorded as MVC (kg).

3. Muscle Endurance Measurement

- Participant maintained 60–80% of MVC.
- Time until fatigue was recorded in seconds.
- Fatigue defined as inability to sustain required force.

Data Recording and Management

- All measurements recorded immediately after testing.
- Data coded to ensure anonymity.
- Entered into Microsoft Excel master sheet.
- Cross-checked for completeness and accuracy.

Statistical Analysis

Statistical analysis was performed using **SPSS version 22.0**.

1. Normality of data assessed using Shapiro–Wilk test.
2. Descriptive statistics expressed as mean ± SD.
3. Pre- and post-examination comparisons performed using:
   - Paired t-test (for normally distributed data)
   - Wilcoxon signed-rank test (for non-normal data)
4. p-value < 0.05 considered statistically significant.

Results

The present study included **100 first-year MBBS students** assessed during two phases:

1. **Pre-examination (Stressed phase)**
2. **Post-examination (Relaxed phase)**

Comparisons were made within the same individuals.

1. Demographic Characteristics

Table 1: Demographic Profile of Study Participants (n = 100)

Variable	Value
Mean Age (years)	19.4 ± 1.2
Age Range	18–23 years
Males	52 (52%)
Females	48 (48%)

The study population represented a relatively homogeneous group of young, healthy medical students.

2. Perceived Stress Scores (PSS-10)

Table 2: Comparison of PSS Scores Between Phases

Phase	Mean ± SD	p-value
Pre-Examination	27.8 ± 4.2	< 0.001
Post-Examination	14.3 ± 3.8	

There was a **statistically significant increase** in perceived stress scores during the pre-examination phase compared to the post-examination phase (p < 0.001).
Pre-examination scores predominantly fell under the **high stress category**, while post-examination scores were mostly in the **moderate stress category**.

3. Maximum Voluntary Contraction (MVC)

Table 3: Comparison of MVC (kg)

Phase	Mean ± SD	p-value
Pre-Examination	28.6 ± 6.4	0.002
Post-Examination	31.9 ± 6.1	

MVC was significantly reduced during the stressed phase compared to the relaxed phase.
This indicates decreased voluntary muscle strength during examination stress.

4. Muscle Endurance Time

Table 4: Comparison of Endurance Time (seconds)

Phase	Mean ± SD	p-value
Pre-Examination	38.5 ± 7.2	0.001

Phase	Mean ± SD	p-value
Post-Examination	45.6 ± 8.4	

Muscle endurance time was significantly lower during the stressed phase.
Participants fatigued earlier during pre-examination assessment.

Overall Findings

1. Examination stress significantly increased perceived stress scores.
2. Maximum voluntary contraction decreased during stress.
3. Endurance time reduced significantly during stress.

These findings demonstrate that examination stress adversely affects skeletal muscle performance.

Conclusion

The present study was conducted to evaluate the effect of examination stress on skeletal muscle function among first-year medical students. The findings clearly demonstrate that examination stress significantly influences both psychological and physiological parameters.

Perceived stress levels were markedly higher during the pre-examination phase compared to the post-examination phase, confirming that examinations act as a significant academic stressor. This psychological stress was objectively associated with measurable reductions in skeletal muscle performance.

Maximum Voluntary Contraction (MVC) was significantly lower during the stressed phase, indicating reduced voluntary muscle strength under examination stress. Similarly, muscle endurance time was decreased during the pre-examination period, suggesting early onset of fatigue.

The results support the hypothesis that activation of stress pathways—particularly the HPA axis and sympathetic nervous system—leads to hormonal, neural, vascular, and metabolic alterations that negatively impact skeletal muscle function. Elevated cortisol levels, increased sympathetic activity, reduced muscle perfusion, and accelerated lactate accumulation may collectively contribute to reduced strength and endurance during periods of academic stress.

Thus, examination stress not only affects mental well-being but also produces measurable physiological consequences in skeletal muscle performance. These findings highlight the importance of early identification of stress in medical students and the integration of structured stress-management interventions within the medical curriculum.

In conclusion, examination stress significantly reduces skeletal muscle strength, endurance, and work capacity among first-year medical students. Addressing academic stress through institutional support systems and preventive strategies may improve both psychological resilience and physiological performance in future healthcare professionals.

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