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Relationship between Serum Creatine Kinase and Skeletal Muscle Injury in Physical Assault Cases

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ABSTRACT

Background: Physical assault frequently results in skeletal muscle injury, yet objective biochemical markers that quantify the degree of trauma remain underutilized in forensic evaluations. Serum creatine kinase (CK) is released following muscle fiber damage and may serve as an adjunct indicator of injury severity.

Objective: To determine the relationship between serum CK levels and the extent of skeletal muscle injury in victims of non-fatal physical assault.

Methods: A cross-sectional study was conducted on 120 adult assault victims presenting to the emergency department of JPMC, Karachi. Serum CK was measured within 6 hours of presentation. Injury severity was graded using a standardized Muscle Injury Score (MIS) based on clinical examination and ultrasound findings. Data were analyzed using SPSS v26. Pearson correlation was used to assess the relationship between CK and MIS.

Results: The mean CK level in assault victims was 612 ± 298 U/L (reference: <190 U/L). CK levels showed a significant positive correlation with muscle injury severity ($r = 0.71$, $p < 0.001$). Patients with mild, moderate, and severe MIS had mean CK levels of 280 ± 96, 620 ± 160, and 1,120 ± 350 U/L, respectively ($p < 0.001$). No significant difference in CK levels was observed between age groups or gender. Blunt trauma from sticks and rods produced significantly higher CK levels than fist blows.

Conclusion: Serum CK is significantly elevated in victims of physical assault and correlates strongly with the severity of skeletal muscle injury. CK measurement can serve as an objective biochemical marker supporting clinical and forensic assessment of trauma severity..

Keywords: Serum Creatine Kinase, Skeletal Muscle Injury, Physical Assault Cases

1. INTRODUCTION

Physical assault is a common medicolegal problem in South Asia, resulting in a wide spectrum of soft-tissue injuries that range from superficial abrasions and contusions to deep muscle crush injuries and lacerations [1].

Skeletal muscle, owing to its large mass, high vascularity, and metabolic activity, is particularly vulnerable in blunt force trauma and often constitutes the principal site of internal injury [2]. Such injuries may contribute not only to local pain and disability but also to systemic complications including rhabdomyolysis and acute kidney injury, especially when muscle damage is extensive or unrecognized [3].

Traditional forensic assessment of assault victims relies heavily on external examination, photographic documentation, subjective grading of injuries, and the victim's statement [4]. These approaches, while essential, are inherently limited by examiner variability, delayed presentation, healing-related changes, and potential inconsistencies in victim accounts. Importantly, significant muscle injury may exist even in the absence of prominent external signs, leading to underestimation of injury severity in medico-legal documentation [5]. This highlights the need for objective, reproducible biological markers that can supplement physical findings.

Creatine kinase (CK) is an intracellular enzyme abundantly present in skeletal muscle, predominantly as the CK-MM isoenzyme [6]. Disruption of muscle fiber integrity leads to leakage of CK into the circulation, making serum CK a sensitive indicator of muscle injury. In clinical practice, CK measurement is routinely used in the diagnosis and monitoring of rhabdomyolysis, crush injuries, strenuous exercise–related muscle damage, and trauma-associated complications [2,3]. The magnitude and temporal pattern of CK elevation have been shown to correlate with injury severity and risk of adverse outcomes, particularly renal impairment [7].

Despite its established clinical utility, the application of CK measurement in forensic evaluation of non-fatal assault remains relatively underexplored [8]. Prior forensic studies have primarily focused on postmortem CK and related muscle or cardiac biomarkers to assess tissue damage and cause of death [6,9]. Limited evidence suggests that antemortem CK levels may help objectively corroborate assault severity, distinguish genuine muscle injury from minor trauma, and support medico-legal opinion when external findings are equivocal [5,10].

Systematic investigation of CK dynamics in assault victims is therefore essential to define optimal sampling windows, clinically and forensically meaningful thresholds, and its role alongside conventional injury assessment. This study investigates the relationship between serum CK levels and the severity of muscle injury following non-fatal physical assault.

2. METHODS

Study Design and Setting

A cross-sectional observational study was conducted at the Emergency Department of JPMC, a tertiary care hospital in Karachi, over six months Janauary 2025 to June 2025; after obtaining ethical approval from IRB.

Participants

Total: 120 patients

Inclusion criteria:

Age 18–60 years

Recent (≤12 hours) physical assault

Blunt trauma (fist, kick, stick, rod, stone)

Exclusion criteria:

Chronic muscle disease

Alcohol/drug intoxication

Recent heavy exercise

Known metabolic or cardiac illness

Injury Assessment

A standardized **Muscle Injury Score (MIS)** was created based on:

Clinical findings: swelling, tenderness, ecchymosis, restricted movement

Ultrasound: muscle fiber disruption, hematoma size, edema

Pain scale

Grade	Symptoms	Signs	Pathologic Correlation	Imaging

Mild	Sharp moderate pain, increasing with activity. Usually capable to continue, no loss of function or strength.	Mild pain on palpation, mild spasm, and subtle swelling. No or minimal loss of strength and ROM (<10°).	0–5% muscle fiber disruption	Ultrasound: No abnormalities or diffuse bleeding with/without focal fiber rupture <5% of the muscle involved.
Moderate	Unable to continue activity (usually slows down the sprint).	Clear loss of strength and ROM (10–25%). Moderate swelling. Palpable defect if >10–20%.	>5–50% disruption with fascial injury	Ultrasound: Focal fiber rupture >5% of the muscle involved with fascial injury, edema, and hemorrhage.
Severe	Immediate severe pain, nearly falls while sprinting.	Complete loss of function. Loss of ROM >25°. Palpable defect.	50–100% disruption of muscle fibers	Ultrasound: Complete muscle ruptures with retraction, fascial injury. MRI: Negative, no structural damage, muscle edema with or without hemorrhage.

MIS Grading:

Generally, a **grade I or "mild"** muscle injury was considered to correspond to stretching or minimal disruption of muscle cells and a clinical presentation characterized by minimal, well localized pain, contracture and hemorrhage, minor disability, a full pain-free ROM (or <10° ROM deficit), and the ability to continue the sporting activity immediately after the injury.

A **grade II or "moderate**" injury was considered to correspond to tearing of a greater number of muscle fibers but without complete muscle rupture, and to a more severe presentation compared with the previous grade, characterized by moderate and poorly localized pain, disability, painful ROM (or 10–25° ROM deficit), and inability to continue the sporting activity, with limping.

A **grade III or "severe"** injury was considered to be a complete muscle rupture, therefore presenting with the worst clinical scenario characterized by the athlete collapsing in pain immediately following the injury, more than 50% loss of motion (or <25° ROM deficit), a rapid muscle circumference decrease of more than 12 mm compared to the healthy contralateral muscle, diffuse pain and hemorrhage.

Blood samples were collected within 6 hours of the subject's arrival to ensure accurate representation of the physiological response to muscle injury. Serum creatine kinase (CK) levels were measured using an enzymatic ultraviolet (UV) kinetic assay, a reliable method for quantifying CK activity. The reference range for CK was set at <190 U/L, which is considered normal in healthy individuals. Elevated CK levels above this threshold indicate muscle damage, making it a key biomarker for assessing injury severity.

Descriptive statistics, including the mean and standard deviation (SD), were used to summarize the data. To compare the differences between groups, an analysis of variance (ANOVA) was conducted. Additionally, Pearson's correlation coefficient was calculated to examine the relationship between serum CK levels and the Muscle Injury Score (MIS). Statistical significance was determined at a p-value of < 0.05, indicating that the results are considered statistically meaningful if this threshold was met.

3. RESULTS

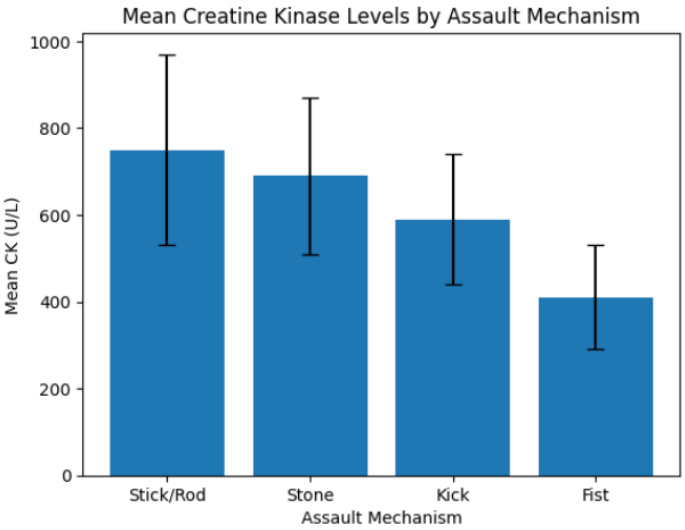
The study population had a mean age of 32.5 ± 10.2 years. Males constituted the majority of participants (n = 84; 70%), while females accounted for 36 cases (30%). Statistical analysis showed no significant influence of age or gender on serum creatine kinase (CK) levels ($p > 0.05$), indicating that variations in CK were independent of these demographic factors.

Serum CK Levels and Injury Severity

MIS Category	n	CK Level (Mean ± SD)
Mild	42	**280 ± 96 U/L**
Moderate	56	**620 ± 160 U/L**
Severe	22	**1,120 ± 350 U/L**

ANOVA demonstrated a highly significant difference in mean creatine kinase (CK) levels across the study groups ($p < 0.001$), indicating that CK values varied significantly with the severity of muscle injury. Furthermore, correlation analysis revealed a strong positive association between serum CK levels and the Muscle Injury Score (MIS), with a Pearson correlation coefficient of $r = 0.71$ ($p < 0.001$). This finding suggests that increasing muscle injury severity is accompanied by a proportional rise in CK levels, supporting the role of CK as a reliable biochemical marker for assessing the extent of skeletal muscle damage.

The mechanism of assault showed a clear impact on mean serum creatine kinase (CK) levels, reflecting the extent of muscle damage produced by different forms of trauma. Assaults involving sticks or rods resulted in the highest mean CK levels (750 ± 220 U/L), suggesting more severe and widespread skeletal muscle injury due to the greater force and surface area involved. Injuries caused by stones were associated with slightly lower but still markedly elevated CK levels (690 ± 180 U/L), indicating substantial blunt muscle trauma. Kicking produced moderate elevations in CK (590 ± 150 U/L), consistent with localized muscle injury of lesser severity. In contrast, fist-related assaults showed the lowest mean CK levels (410 ± 120 U/L), reflecting comparatively limited muscle damage. Overall, these findings demonstrate a graded increase in CK levels corresponding to the severity and force of the assault mechanism, supporting CK as a useful biochemical indicator of trauma intensity.



4. DISCUSSION

This study demonstrates that serum creatine kinase (CK) rises proportionally with the severity of skeletal muscle injury in victims of non-fatal physical assault. The observed strong positive correlation ($r = 0.71$) supports the role of CK as an objective biochemical marker that complements traditional clinical and forensic assessment. Similar correlations between CK elevation and muscle injury severity have been documented in trauma and critical care settings, where CK has been shown to reflect the extent of myocyte membrane disruption and necrosis [10,11].

The variation in CK levels with the type of assault observed in the present study is consistent with established pathophysiological mechanisms. Assaults involving blunt weapons produced significantly higher CK elevations compared to punches or kicks, likely due to deeper tissue compression, muscle crush, and hematoma formation. Comparable findings have been reported in sports medicine and trauma literature, where blunt impact and eccentric muscle injury result in greater CK release than superficial trauma [12,13]. These biochemical patterns also resemble those seen in mild rhabdomyolysis, further reinforcing the biological plausibility of CK as a marker of muscle damage in assault cases [14].

An important methodological strength of this study is the early timing of CK measurement. Samples were obtained within six hours of injury, capturing the early rising phase of CK release. Previous studies indicate that serum CK typically begins to rise within 2–12 hours after muscle injury, peaks at 24–36 hours, and declines gradually over several days [15,16]. Therefore, higher CK levels might have been detected in cases with delayed presentation, suggesting that early sampling may underestimate peak injury-related enzyme release.

From a forensic perspective, the findings have significant implications. Objective biochemical documentation of muscle injury can strengthen medico-legal opinions, particularly in cases where external injuries are minimal or disputed. Prior forensic research has highlighted the limitations of visual injury assessment alone and advocated for adjunct laboratory markers to improve reliability and reproducibility [17]. CK measurement may assist in differentiating simple from grievous hurt by providing biochemical evidence of deep tissue involvement, thereby supporting legal classification under penal codes

[18].

Additionally, CK estimation may help corroborate victim narratives, especially in alleged assault cases where histories are contested or when there is suspicion of fabricated or exaggerated claims. Similar applications of biochemical markers have been proposed in forensic psychiatry and custodial violence investigations, where CK elevation has been associated with physical struggle and trauma [19,20]. However, interpretation must remain cautious, accounting for confounders such as recent exertion, seizures, intramuscular injections, or underlying myopathies [21].

Overall, the present findings support the integration of serum CK estimation into the medico-legal evaluation of physical assault victims as a supportive, objective tool rather than a standalone determinant

5. CONCLUSION

Serum CK is significantly elevated in victims of physical assault and shows a strong correlation with the severity of skeletal muscle injury. CK measurement serves as a valuable biochemical adjunct to clinical and forensic examination, adding objectivity to medicolegal assessments.

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