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Acute post-match changes in c-reactive protein and haematological indices in field hockey players

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Abstract
Background: Field hockey is an intermittent, high-intensity team sport that imposes significant physiological stress, yet little is known about the acute inflammatory and immune responses of elite female players. Biomarkers such as C-Reactive Protein (CRP), White Blood Cell (WBC) count, and the Neutrophil-to-Lymphocyte Ratio (NLR) provide valuable insight into these processes.
Aim: This study investigated pre- and post-match changes in CRP, WBC count, and NLR in elite female field hockey athletes.
Methods: Thirty national-level female field hockey players (aged 18-25 years) participated. Venous blood samples were collected 24 hours before and 24 hours after an official competitive match. CRP was quantified using an automated immunoturbidimetric assay, while WBC counts and differentials were analysed with an automated haematology analyser to calculate NLR. Data were analysed using descriptive statistics and paired-sample t-tests, with significance set at $p<0.05$. Effect sizes (Cohen's d) were calculated to assess the magnitude of change.
Results: Significant increases were observed across all biomarkers post-match. CRP rose from 0.89±0.26 to 3.55±1.39 mg/L (t = 11.89, $p<0.001$, d = 2.17), WBC increased from 6.28±0.52 to 7.77 ± 1.01 $\times 10^9$/L (t = 8.63, $p<0.001$, d = 1.57), and NLR rose from 1.67±0.28 to 2.73±0.67 (t = 9.24, $p<0.001$, d = 1.69).
Conclusion: A single competitive field hockey match induces marked elevations in CRP, WBC count, and NLR, reflecting acute inflammatory and immune activation. These findings highlight the physiological burden of match-play and underscore the importance of structured recovery strategies to optimise performance and safeguard health. The study also provides much needed baseline data for female athletes, addressing the underrepresentation of women in sports science. Future research should extend these findings by adopting longitudinal approaches across competitive seasons and examining additional biomarkers of stress and recovery.

Keywords: Field hockey, female players, c-reactive protein (CRP), white blood cells (WBC), neutrophil-to-lymphocyte ratio (NLR), inflammation

Introduction
Field hockey is a demanding, high-intensity intermittent team sport known for its repeated sprints, rapid changes of direction and sustained aerobic demands, all of which place significant physiological pressure on athletes' musculoskeletal, metabolic, and immune systems. While this physical load is well-documented in sports like soccer, the specific evidence for field hockey, especially among female athletes, remains sparse, highlighting a critical gap in sports science research.
Central to understanding this physiological stress are certain biomarkers. A well-known acute-phase protein, C-Reactive Protein (CRP) is created by the liver in reaction to pro-inflammatory cytokines, including IL-6. Although it usually stays low in athletes who are well-trained, it rises in the hours after vigorous physical activity, usually reaching its high 13 hours after a game. Soccer players have shown that it returns to baseline around 48 hours (A. Souglis *et al*., 2018) [6]. White Blood Cell (WBC) counts and the Neutrophil-to-Lymphocyte Ratio (NLR) also serve as key indicators of the body's immune response. For instance, studies in female futsal athletes reported that WBC counts peak immediately after a match and remain elevated for at least 24 hours (A. Souglis *et al*., 2023) [7].

The NLR, offering a simple yet effective measure of systemic inflammation, further refines the understanding of immune dynamics in response to high-performance sport. Although research has explored these biomarkers in endurance sports and male cohorts, the female-specific responses in field hockey are underrepresented. Notably, evidence suggests that CRP and NLR reference ranges vary by gender, with female athletes generally presenting higher baseline NLRs, underscoring the need for sex-specific interpretation of inflammatory status (Wang *et al*., 2025) [9]. Moreover, a study comparing male and female soccer players found that both sexes showed similar CRP responses peaking at 24 hours post-match, but with certain inflammatory markers differing by sex (e.g., TNF-α levels) (A. G. Souglis *et al*., 2015) [8].

The depth of current knowledge in team sports like football shows a notable deficiency in evidence, focusing on female field hockey players particularly regarding acute, match-specific fluctuations in these biomarkers. Given the sport's intermittent high-intensity nature, understanding the immune and inflammatory responses that follow competition is vital. Such insight can illuminate athlete recovery, inform training periodisation, and contribute to safeguarding player health.

This study aims to address these research gaps by exploring pre- and post-match changes in CRP, WBC count, and NLR among female field hockey players. By profiling these biomarker responses in a real-world competitive setting, the research seeks to guide better recovery monitoring, effective training load management, and health preservation in women's high-performance sport.

Methodology

Study Design

This study utilised an observational, repeated-measures design to assess acute changes in inflammatory and haematological biomarkers in response to competitive match-play. Data were collected 24 hours before and 24 hours after a single official fixture to replicate real-world competitive demands and preserve ecological validity.

Participants

Thirty (30) female field hockey players aged 18-25 years participated in the study. Inclusion criteria required athletes to be national-level players, actively training, and free from injury or medical conditions. Exclusion criteria included any recent illness, infection, or use of medication known to affect immune or inflammatory function.

Procedures

Venous blood samples were collected at two time points: 24 hours before the match (pre-match baseline) and 24 hours after the match (post-match). The competitive match was conducted under official tournament conditions. No external interventions were introduced to maintain ecological validity. Blood collection was performed using sterile venepuncture techniques, with samples transported under controlled conditions to the testing laboratory.

Biochemical and Haematological Analysis

All blood samples were processed in an accredited clinical laboratory under standardised protocols for serum preparation and haematological analysis. C-Reactive Protein (CRP) concentrations were determined using an automated immunoturbidimetric assay, while White Blood Cell (WBC) and differentials were obtained through a fully automated haematology analyser to derive the neutrophil-to-lymphocyte ratio (NLR). All analyses adhered to laboratory quality assurance standards and calibration procedures to ensure reliability and reproducibility. The study received ethical permission, and each participant gave written informed consent before any data was collected. The examination of acute post-match inflammatory and haematological responses in female hockey players was supported by this meticulous methodological approach, which also guaranteed the quality of biomarker measures.

Results

Samples were analysed in an accredited clinical laboratory. Statistical analysis was conducted using paired-sample *t*-tests, with significance set at $p<0.05$. Descriptive statistics (mean ± SD) were calculated for each biomarker.

Table 1: Descriptive Statistics for Biomarkers Pre- and Post-Match (N = 30)

Variables	N	Pre-Match Mean ± SD	Post-Match Mean ± SD
CRP (mg/L)	30	0.89 ± 0.26	3.55 ± 1.39
WBC ($\times10^9$/L)	30	6.28 ± 0.52	7.77 ± 1.01
NLR (ratio)	30	1.67 ± 0.28	2.73 ± 0.67

Table 1 presents the descriptive statistics for CRP, WBC, and NLR before and after the competitive match. CRP values increased from a baseline of 0.89 mg/L to 3.55 mg/L post-match, showing a robust inflammatory response. WBC rose from 6.28 $\times10^9$/L to 7.77 $\times10^9$/L, while NLR increased from 1.67 to 2.73, indicating immune system activation following match play.

Table 2: Paired t-Test Results for Biomarker Change (N = 30)

Variables	N	Mean Difference (Pre-Post)	t (df = 29)	p- Value	Cohen's d
CRP (mg/L)	30	+2.66	11.89	<0.001	2.17 (Large)
WBC ($\times10^9$/L)	30	+1.49	8.63	<0.001	1.57 (Large)
NLR (ratio)	30	+1.06	9.24	<0.001	1.69 (Large)

Table 2 summarises the results of paired-sample *t*-tests. All biomarkers (CRP, WBC, and NLR) showed significant increases after match play ($p<0.001$). Effect sizes were large (Cohen's $d > 1.5$), underscoring that these changes were not only statistically significant but also practically important for physiological monitoring. CRP exhibited the greatest increase, nearly quadrupling post-match, suggesting strong activation of acute-phase inflammatory processes.

Discussion

This study confirmed that a single competitive field hockey match triggers significant inflammatory and immune responses in elite female athletes. All three markers CRP, WBC, and NLR, showed pronounced increases 24 hours post-match, indicating the physiological toll of high-intensity intermittent sport.

The elevation in C-Reactive Protein (CRP) aligns with findings in similar team sports. For instance, peak CRP levels have been observed around 24 hours post-match in soccer, reflecting acute-phase inflammatory activity following intense exertion (Khaniyo, 2021) [2]. This supports the idea that CRP is a sensitive indicator of acute physiological stress.

The significant rise in White Blood Cell (WBC) count post-match is consistent with the well-documented phenomenon of leukocytosis, where catecholamine-mediated mobilisation of leukocytes into circulation occurs during and after exercise (Sand *et al*., 2013) [5]. This reflects the body's acute immune mobilisation, potentially supporting tissue repair and response to microtrauma.

Similarly, the Neutrophil-to-Lymphocyte Ratio (NLR), a simple yet robust marker of systemic stress, nearly doubled post-exercise in this cohort. Elevated NLR has been proposed as a sensitive metric for systemic inflammation and stress responses, making it a useful candidate for athlete monitoring (Baskerville *et al*., 2024) [1].

These findings carry practical implications: structured recovery protocols should be prioritised, as persistent elevations of inflammatory and immune markers may compromise training adaptation, performance, or increase illness risk (Peake *et al*., 2017) [4]. Furthermore, this study adds to the currently limited evidence base regarding female players physiological responses, addressing a noted gap where women are underrepresented in sports science research (McGuinness *et al*., 2019) [3].

Conclusion

The present study provides clear evidence that a single competitive field hockey match elicits significant acute changes in inflammatory and haematological markers in elite female athletes. The observed increases in CRP, WBC count, and NLR within 24 hours post-match highlight the physiological strain associated with high-intensity, intermittent sport and underline the importance of closely monitoring recovery in this population. These results suggest that competitive match-play not only challenges aerobic and anaerobic energy systems but also provokes a measurable immune and inflammatory response, which, if not managed appropriately, may compromise recovery and increase vulnerability to illness or injury.

From a practical perspective, these findings support the integration of biomarker assessment into athlete support programmes, enabling coaches, sport scientists, and medical staff to better align training loads and recovery strategies. Approaches such as optimised sleep, nutritional support, and structured recovery sessions could be strategically applied when biomarker elevations are detected, reducing cumulative fatigue and maintaining performance readiness. Furthermore, this study contributes valuable baseline data on female field hockey players, addressing the persistent underrepresentation of women in sports science research.

Future investigations should build on these findings by adopting longitudinal designs that track biomarker fluctuations across an entire competitive season, while also examining additional markers such as interleukin-6, cortisol, and oxidative stress indices to capture the complexity of physiological adaptation. Comparative studies between male and female athletes, as well as across different playing levels, would further enhance understanding of sex-specific and performance-level responses. Ultimately, such research will enable the development of personalised monitoring systems that protect athlete health while maximising performance potential.

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