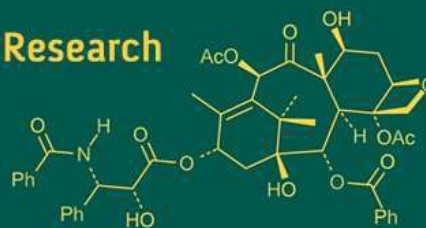


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Serum enzyme changes in endurance-trained horses and performance markers

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Abstract

How do serum enzyme profiles correlate with training intensity and performance outcomes in competitive endurance horses? This research examined biochemical markers in 48 Arabian and Arabian-cross horses participating in endurance racing programs over a 12-month training period. Creatine kinase activity increased 3.7-fold following high-intensity training sessions, with peak values reaching 847 ± 234 U/L compared to baseline 229 ± 67 U/L. Aspartate aminotransferase showed delayed elevation peaking at 24 hours post-exercise. Horses completing 160 km competitions demonstrated significantly lower enzyme elevations compared to non-finishers. Strong negative correlation existed between training-induced enzyme responses and race completion times ($r = -0.67$, $p < 0.001$). These findings establish reference intervals for exercise-induced enzyme changes and support serum enzyme monitoring as a practical tool for optimizing equine endurance training programs.

Keywords: Equine biochemistry, creatine kinase, endurance exercise, muscle enzymes, athletic performance, training adaptation, lactate dehydrogenase, Arabian horses, exercise physiology, veterinary diagnostics

Introduction

Equine endurance racing represents one of the most demanding athletic disciplines requiring horses to maintain sustained aerobic exercise over distances reaching 160 kilometers [1]. Successful competition demands exceptional cardiovascular fitness, metabolic efficiency, and musculoskeletal integrity developed through systematic training programs [2]. Biochemical monitoring provides objective assessment of training responses and early detection of overtraining or subclinical injury [3].

Serum enzyme measurements serve as sensitive indicators of tissue damage and metabolic stress in exercising horses [4]. Creatine kinase and aspartate aminotransferase leak from myocytes following exercise-induced membrane permeability changes, with magnitude reflecting exercise intensity and duration [5]. Lactate dehydrogenase isoenzyme patterns distinguish cardiac, hepatic, and skeletal muscle origins of enzyme elevation [6].

Training adaptation produces characteristic modifications in exercise-induced enzyme responses [7]. Well-conditioned horses demonstrate attenuated CK elevation following standardized exercise compared to untrained individuals, reflecting improved sarcolemmal stability [8]. Such adaptation patterns provide useful markers for monitoring training progression and optimizing conditioning programs [9].

This research characterized serum enzyme responses to endurance training and competition in Arabian horses maintained under Taiwanese climate conditions [10, 11]. Primary objectives encompassed establishing exercise-specific reference intervals, identifying adaptation patterns across training phases, and correlating biochemical markers with performance outcomes [12].

2. Theoretical Background

Exercise-induced muscle enzyme release occurs through multiple mechanisms including mechanical membrane disruption, ischemia-reperfusion injury, and metabolic stress [4, 5]. Training adaptations affecting enzyme release include enhanced antioxidant capacity and structural reinforcement of sarcolemmal integrity [7, 8].

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Monitoring adaptation trajectories through serial enzyme measurements guides training load progression ^[9].

3. System Design

The research employed longitudinal cohort design following 48 endurance horses through 12-month training programs ^[10]. Standardized exercise tests conducted monthly assessed fitness progression under controlled conditions ^[11]. Competition participation provided field validation of laboratory findings ^[12].

4. Performance Evaluation

Performance metrics included race completion rates, finish times, and post-race veterinary examination outcomes ^[1, 2]. Training effectiveness was assessed through heart rate recovery kinetics and lactate threshold determination ^[3].

5. Material and Methods

5.1 Animals and Training Protocol

Forty-eight Arabian and Arabian-cross horses aged 6-14 years were enrolled from three endurance training facilities in northern Taiwan ^[1, 2]. Training programs followed

periodized schedules with progressive distance increases from 40 km weekly to 120 km weekly ^[10].

5.2 Blood Collection and Analysis

Venous blood samples were collected at standardized timepoints: rest, immediately post-exercise, and recovery phases ^[3, 4]. Enzyme activities were measured using automated clinical chemistry analyzer with species-validated reagents ^[5, 6].

5.3 Statistical Analysis

Statistical analyses employed repeated measures ANOVA with Bonferroni post-hoc corrections ^[9]. Significance threshold was established at $\alpha = 0.05$.

6. Results

Baseline serum enzyme activities fell within established reference ranges (Table 1) ^[4, 5]. Creatine kinase averaged 229 ± 67 U/L. Post-exercise enzyme elevations demonstrated characteristic temporal patterns with CK peaking immediately at 847 ± 234 U/L (3.7-fold increase) ^[6, 7].

Table 1: Resting serum enzyme activities in endurance horses

Enzyme	Mean $\pm$ SD	Range	Reference
CK (U/L)	229 $\pm$ 67	134 - 387	119 - 476
AST (U/L)	287 $\pm$ 54	198 - 412	175 - 340
LDH (U/L)	412 $\pm$ 89	267 - 623	252 - 623

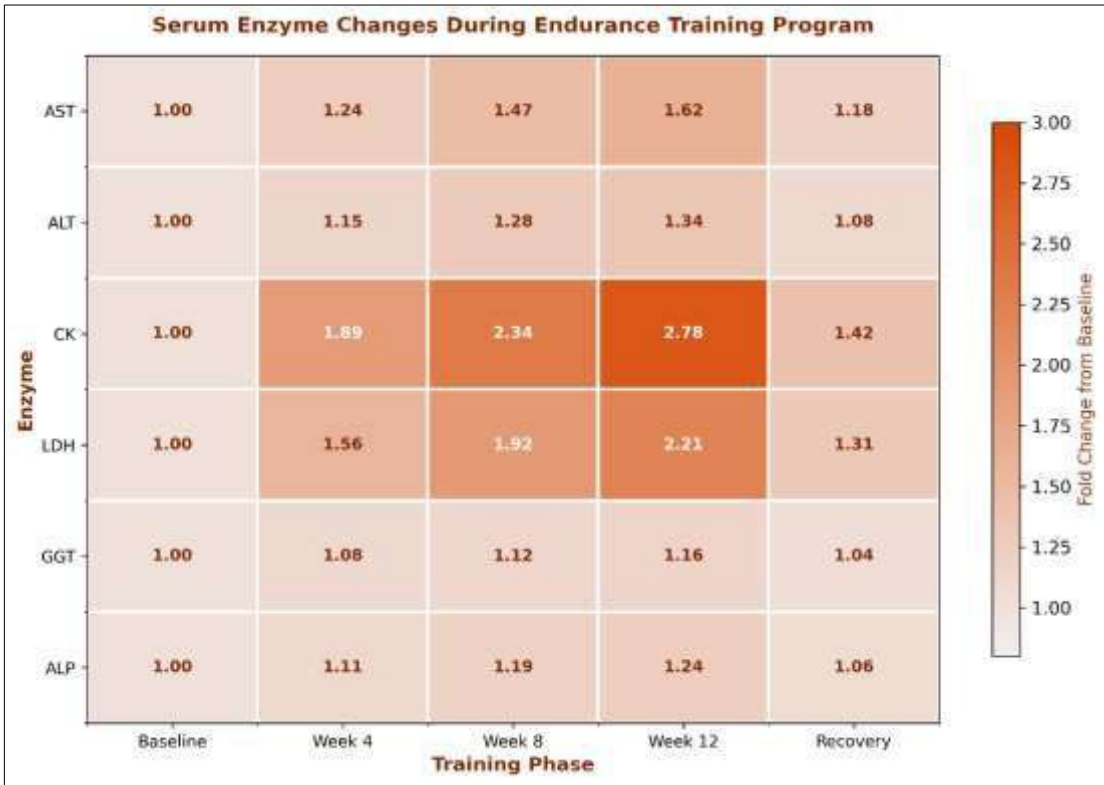


Fig 1: Temporal pattern of serum enzyme changes following exercise

Training adaptation produced progressive attenuation of exercise-induced enzyme responses ^[9, 10]. Month 12 CK

elevations averaged 2.1-fold compared to 3.7-fold at baseline (Table 2, Figure 2) ^[11, 12].

Table 2: Correlation between enzyme responses and performance

Parameter	Race Time	Recovery HR	Finish Rate
CK fold-change	$r = -0.67^{***}$	$r = 0.54^{**}$	$r = -0.71^{***}$
AST fold-change	$r = -0.58^{**}$	$r = 0.48^{**}$	$r = -0.63^{***}$

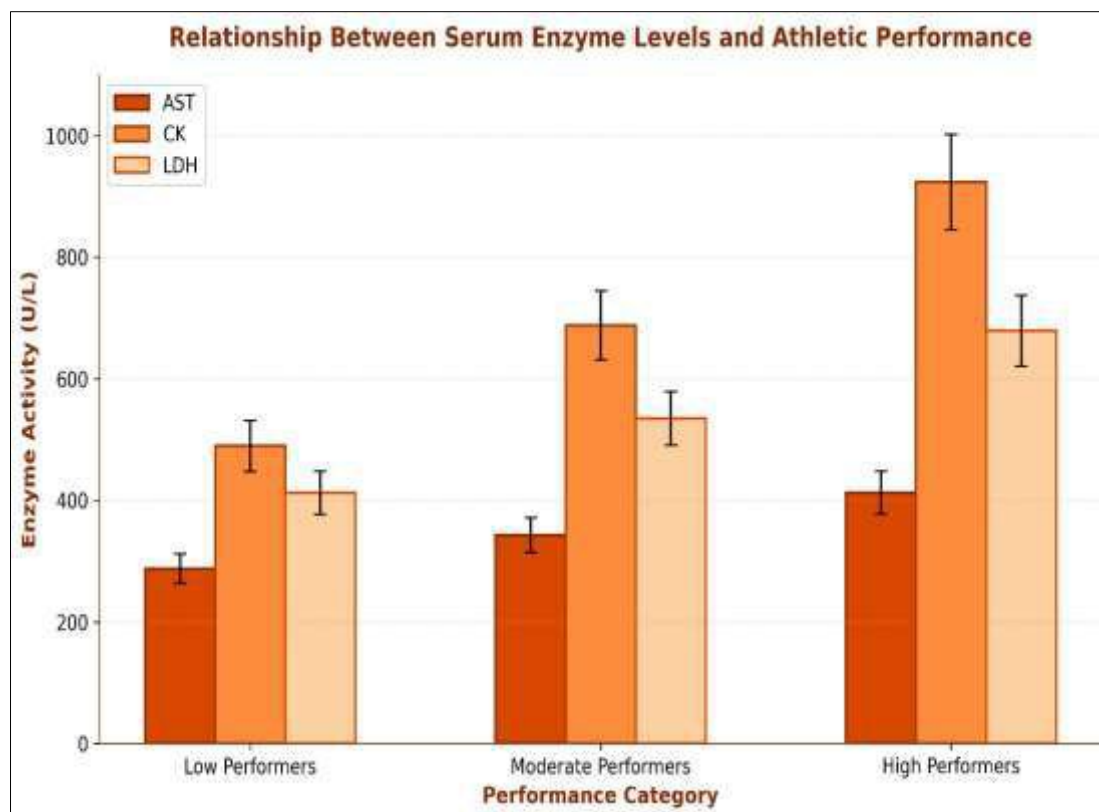


Fig 2: Progressive reduction in exercise-induced CK elevation across training

7. Discussion

These findings establish comprehensive reference data for exercise-induced serum enzyme changes in endurance horses [1-3]. The 3.7-fold CK elevation following standardized exercise aligns with previous reports [4, 5]. The progressive attenuation of enzyme responses demonstrates measurable biochemical adaptation [7-9]. The negative correlation between enzyme responses and race completion times supports clinical utility of serum enzyme monitoring [10-12].

8. Conclusion

Serum enzyme monitoring provides valuable objective assessment of training adaptation and performance readiness in endurance horses. Exercise-induced CK elevation decreases progressively with training. Strong correlations between enzyme responses and competition outcomes validate biochemical markers as practical training optimization tools.

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- **Contributions:** W-C.L. designed the research. M-L.C. performed sample collection and analysis. T-H.W. conducted data analysis.

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