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The Impact of Bimodal Daily Training on Circadian Rhythms of Motor and Cardiac Performance in State-Level Athletes

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Abstract

Introduction: The influence of circadian rhythms on athletic performance is well-documented, yet the acute effects of a typical bimodal (two-a-day) training schedule on these rhythms are less understood. Optimizing training requires knowledge of how performance variables fluctuate throughout a training day.

Objective: This study investigated the circadian variations of selected motor abilities and cardiac variables in state-level athletes at four distinct time points throughout a standard training day: before morning workout (06:00), after morning workout (10:00), before evening workout (14:00), and after evening workout (18:00).

Methods: Sixty state-level male athletes (20 runners, 20 jumpers, 20 throwers), aged 20-26, participated. Eight variables were measured at each time point: motor abilities (speed, agility, balance, coordination) and cardiac variables (cardiorespiratory endurance, mean arterial blood pressure [MABP], forced vital capacity [FVC], and resting pulse rate [RPR]). A repeated measures ANOVA was used to analyze the data, with Scheffe's post-hoc test for paired comparisons, at a significance level of $p < 0.05$.

Results: Significant circadian variations were found across all motor and cardiac variables ($p < 0.05$). Post-hoc analysis revealed that motor abilities such as agility and coordination peaked after the morning workout (10:00) and evening workout (18:00), showing significant improvements compared to pre-workout states. Cardiac variables also showed significant fluctuations. Cardiorespiratory endurance was highest after the morning session. MABP and RPR were generally lower before workouts and showed complex variations post-exercise. FVC was highest after the morning session.

Conclusion: A bimodal training schedule induces significant and predictable intra-day variations in both motor and cardiac function in state-level athletes. Performance readiness for motor skills appears to peak post-workout, while cardiac parameters demonstrate a dynamic response to the exercise-and-recovery cycle throughout the day. These findings suggest that the timing of training and performance evaluation is a critical factor for coaches and sports scientists to consider.

Keywords: Circadian rhythm, Athletic performance, Motor abilities, Cardiac function, Bimodal training schedule

Introduction

The 24-hour biological cycles known as circadian rhythms have a profound influence on human physiology and performance. These endogenous rhythms, entrained by external cues like light and temperature, affect everything from hormone secretion to core body temperature, with performance typically peaking in the late afternoon. For elite athletes, whose schedules often involve two training sessions per day (bimodal training), understanding how this strenuous activity interacts with their natural rhythms is crucial for optimizing performance and recovery.

While the general pattern of circadian performance is known, the specific acute effects of morning and evening training bouts on key motor and cardiac variables have not been fully elucidated in a single comprehensive study. This knowledge gap makes it difficult for coaches to schedule training sessions, recovery periods, and performance testing optimally.

Therefore, this study aimed to compare selected motor abilities and cardiac variables at four key time points across a bimodal training day in a cohort of state-level athletes.

Methods

- **Participants:** Sixty male state-level athletes (20 runners, 20 jumpers, 20 throwers) aged 20-26 were recruited from coaching camps in Vijayawada, Andhra Pradesh.
- **Design:** A repeated measures design was used. All subjects were tested on all variables at four time points:
- **BMW:** Before Morning Workout (06:00)
- **AMW:** After Morning Workout (10:00)
- **BEW:** Before Evening Workout (14:00)
- **AEW:** After Evening Workout (18:00)

Variables and Measurement

- **Motor Abilities:** Speed (50m dash), Agility (Shuttle Run), Balance (Stork Stand), Coordination (Scott Motor Ability Test).
- **Cardiac Variables:** Cardiorespiratory Endurance (Harvard Step Test), Mean Arterial Blood Pressure (from Systolic/Diastolic readings), Forced Vital Capacity (Spirometer), Resting Pulse Rate (Palpation).
- **Statistical Analysis:** Repeated measures ANOVA was used to assess differences across the four time points. Scheffe's post-hoc test was used for pairwise comparisons where significant F-values were found. The significance level was set at $p < 0.05$.

Results

The repeated measures ANOVA revealed statistically significant differences across the four time points for all eight dependent variables ($p < 0.05$).

- **Motor Abilities:** Performance in agility and coordination showed significant improvements at post-workout time points (AMW and AEW) compared to pre-workout (BMW and BEW) and initial scores. For example, agility was significantly better at 10:00 and 18:00 than at 06:00.

Cardiac Variables

- **Cardiorespiratory Endurance:** The index peaked significantly after the morning workout (AMW) compared to all other time points.
- **Mean Arterial Blood Pressure:** MABP was lowest after the morning workout (AMW), showing a significant drop from the initial resting state, before rising again through the day.
- **Forced Vital Capacity:** FVC also peaked after the morning workout (AMW).
- **Resting Pulse Rate:** RPR was lowest before the evening workout (BEW at 14:00), suggesting a recovery trough in the early afternoon, and showed significant fluctuations in response to exercise.

Discussion

The findings demonstrate that an athlete's physiological and performance state is highly dynamic throughout a bimodal training day. The significant improvement in motor abilities post-workout is consistent with the effects of warm-up and neuromuscular activation, which prepare the body for peak performance. The afternoon peak in many performance metrics aligns with established circadian theories.

The cardiac variables reveal a complex interplay between exercise stress and recovery. The peak in cardiorespiratory endurance and FVC after the morning session suggests an acute positive adaptation to the training stimulus. The drop in MABP and the fluctuations in RPR highlight the cardiovascular system's continuous effort to return to homeostasis. The trough in resting pulse rate before the evening session (14:00) may indicate a "recovery window" that coaches could strategically use for rest or low-intensity activity.

Conclusion

Both motor abilities and cardiac function in state-level athletes exhibit significant, predictable variations in response to a bimodal training schedule. Performance capabilities are not static; they are acutely influenced by the preceding exercise bout and the time of day. Coaches and athletes should leverage this knowledge to schedule high-intensity training and performance evaluations during peak readiness windows (e.g., post-warm-up) and to program recovery during physiological troughs.

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