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Analysis of psychophysiological strain in response to endurance exercise in military personnel.

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Abstract

Background: During exercise, athletes experience a significant elevation in physiological strain, influenced by a multitude of internal and external factors, including physical and environmental conditions. These factors dictate how different organ systems respond to physical activity. This study aims to investigate the psychophysiological strain reactions to endurance training in military male runners.

Methodology: A cohort of 75 male military runners, engaging in daily 90-minute exercise routines and aged between 20 and 30, were recruited for the study. The study assessed various physiological variables in military runners, encompassing lactate threshold (LT), maximum oxygen uptake (VO_2 max), and percentage heart rate reserve (%HRR). Additionally, psychological assessments were conducted using the Brunel Mood Scale and Borg's Rate of Perceived Exertion.

Results: The findings revealed a gradual increase in heart rate (HR) and VO_2 max as running intensity escalated. Notably, the runners' perceived exertion rate rose following competitive running events, concomitant with a decrease in their positive mood scale ratings. This trend reflected their disappointment stemming from their performance outcomes.

Conclusion: The study highlights that VO_2 max and LT serve as robust indicators of male runners' potential. Furthermore, the evaluation of runners' mood and perception of exertion before and after the sprint demonstrated an augmentation in negative emotions post-exercise.

Keywords

VO_2 max, Exercise, Military, Lactate Threshold, Heart Rate Reserve.

Introduction

During exercise, athletes experience a significant physiological strain influenced by various internal and external factors, including physical and environmental conditions, that impact how their organ systems respond to physical activity[1]. Athletes across various disciplines demonstrate diverse physiological responses to stress compared to non-athletes, with cardiac function often measured through heart rate variability, VO_2 max, and lactate levels[1]. A runner's fitness is comprehensively assessed through cardiovascular status and performance metrics, which are closely tied to heart rate response[2].

A runner's speed and performance duration are intricately linked to their VO_2 max levels, particularly in long-distance running scenarios where maintaining speed is crucial until the lactate threshold is approached[3]. Radman et al. suggest that diminishing performance may result from physiological strain surpassing the optimal lactate threshold[4]. Additionally, superior performance has been associated with the ability of muscle ion channels to preserve energy for muscle contraction in response to increasing workload, thus delaying lactic threshold production and subsequent exhaustion[5,6]. The central nervous system plays a pivotal role in allocating motor units for exercise engagement during competition[7].

Performance disparities among runners in competitive events underscore individual responsiveness to intensive running[8]. Exercise impacts heart rate response and enhances cardiac function, often resulting in changes in cardiac muscle size and potential. Research indicates that effective running training may involve intervals of high-intensity exercise instead of continuous training, leading to improved heart rate response. Heart rate is a reliable metric for estimating cardiorespiratory fitness before, during, and after exercise, demonstrated through repeatable tests[9]. Heart rate variability is a practical indicator of cardiac control mechanisms, physiological status of athletes, and cost-effective assessment[10].

Maximal oxygen consumption (VO_2 max) reflects an individual's capacity to produce ATP in response to aerobic exercise, with higher levels indicating improved fitness under endurance training programs[11,12]. VO_2 max is influenced by a range of factors from psychological alertness to physiological markers such as genetics, gender, age, and training intensity[13,14]. The accumulation of lactic acid in active muscles during exercise, determined by workload and intensity, marks the transition from aerobic to anaerobic metabolism, known as the lactate threshold[15]. This threshold is influenced by individual factors like muscle size and type, exercise form, and muscle carbohydrate levels, as well as environmental factors including temperature, altitude, and exercise conditions[16]. Runners' varied metabolic responses to training protocols result in different outcomes, where higher lactate threshold values indicate efficient bodily systems during exercise[17].

The influence of exercise on mood has been well-documented[18-20]. The Borg scale has been employed to assess both psychological and somatic exertion in relation to exercise intensity and self-perceived effort[21-24]. Thus, this study aims to investigate psychophysiological strain responses to endurance training in military male runners. Additionally, it seeks to assess and compare Heart Rate Reserve, VO_2 max, Lactate Threshold levels, perceived performance, and mood changes in both skilled and non-skilled male runners.

Methodology

This observational study was conducted at a military battle school located in the cantonment area of Lahore. The study received ethical approval from the institutional review committee. A total of 75 male military runners participated in the study, with each participant providing written informed consent. The inclusion criteria consisted of healthy male military runners from diverse ethnic backgrounds, aged between 20 and 30, who engaged in a daily routine of 90 minutes of endurance workouts. Paramedical staff conducted regular assessments of participants' basic vitals before commencing sprint exercises. Runners with less than 90 minutes of routine exercise or with known serious medical conditions were excluded from the study.

Measurement of %HRR & Cardiovascular Assessment

Heart rate data was collected using radio telemetry and a wristwatch (PM 62, Beurer, Germany) during 15-second intervals up to the 12th minute of consecutive running. The Karvonen Formula was applied to calculate %HRR. Additionally, the distance covered by each runner was recorded in miles using the Polar treadmill distance meter after 12 minutes of running. The Cooper Test Formula was utilized to estimate the maximum oxygen uptake. The lactate threshold (LT) was approximated by averaging the heart rate during the last 20 minutes of exercise, monitored using a heart rate monitoring wristwatch.

Mood Analysis and Perceived Exertion

Mood analysis was conducted while the runners were under the pressure of competitive running. Prior to beginning the running sprint, participants were requested to complete the Brunel Mood Scale (BRUMS) questionnaire. This questionnaire comprises 32 items assessing positive and negative emotions. Participants indicated their responses on a numerical rating scale ranging from zero to four (0 = not at all, 1 = a bit, 2 = moderate, 3 = enough, 4 = extremely). Cumulative scores were computed for various mood dimensions, including anger, confusion, depression, fatigue, tension, vigor, calmness, and happiness. Following the conclusion of the running sprint, participants were once again asked to complete the same BRUMS questionnaire to assess their mood after the strenuous exercise.

Perceived exertion during competitive running was evaluated using Borg's Rating of Perceived Exertion (RPE) scale, which ranges from 6 to 20, with endpoints signifying very light to very hard exertion levels. Participants were instructed to rate their perceived exertion on the RPE scale both before and after the exercise.

Statistical Analysis

Data analysis was performed using SPSS version 20. Descriptive statistics, including mean and standard deviation, were used to present the variables. A paired sample t-test was employed to compare pre-test and post-test values, with statistical significance set at $P < 0.05$.

Results

In Table 1, the mean values and standard deviations of physiological parameters are presented for both good and weak runners. A significant difference was observed in %HRR, VO^2 max, and LT between the two groups.

Table 1: Physiological Variation in runners after exercise.

Parameters	Good	Weak	p-value
%HRR	75.8±4.34	73.5±9.37	0.002*
VO^2 max	59.8±7.78	33.18±4.81	0.001*
LT	169.7±4.65	150.6±9.25	0.004*

*p<0.05 was considered statistically significant.

Table 2 highlights the psychological changes before and after exercise. The mean scores and standard deviations for various mood sub-scales are provided. Notable differences were found in calmness, anger, tension, depression, vigor, fatigue, confusion, and happiness scores following the sprint.

Table 2: Psychological Variation before and after exercise.

Mood sub-scales	Before Sprint	After Sprint	p-value
Calmness	7.92±2.61	7.32±2.71	0.001*
Anger	5.0±3.27	5.80±3.02	0.001*
Tension	4.58±2.26	5.04±2.84	0.002*
Depression	4.82±2.84	5.76±3.26	0.004*
Vigor	9.42±3.00	8.64±3.65	0.002*
Fatigue	6.1±2.95	5.32±2.74	0.002*
Confusion	5.64±2.79	5.32±2.79	0.001*
Happy	9.4±3.30	7.58±3.88	0.001*

*p<0.05 was considered statistically significant

Table 3 showcases the Rate of Perceived Exertion (RPE) before and after exercise. The mean RPE increased significantly from before to after the sprint, indicating the perceived level of exertion during the exercise.

Table 3: Rate of Perceived Exertion before and after exercise.

Perceived Exertion	Before Sprint	After Sprint	p-value
RPE	11.3±2.65	14.34±3.43	<0.001*

*p<0.05 was considered statistically significant

Discussion

The aim of this study was to assess the psychophysiological strain response to endurance exercise, including parameters like %heart rate reserve, VO_2 max, and lactate threshold, alongside psychological mood assessment in military runners. This approach aligns with previous research emphasizing the importance of monitoring both physiological and psychological aspects of runners' performance[25,26]. As supported by Looney et al., our findings confirm that heart rate gradually elevates in accordance with the intensity of exercise as represented by %HRR[27].

The categorization of runners as good and weak based on VO_2 max outcomes from Cooper's test revealed stable results, with better runners demonstrating higher VO_2 max values and vice versa. Similar findings have been reported, indicating a weak relationship between %HRR and VO_2 max in recent studies[28]. This incongruence between VO_2 and HR in military field tests further supports the observed variation in %HRR among individuals with differing fitness levels[29]. It's plausible that the disparity in %HRR among good and weak runners could be attributed to the relative working intensity, as individuals with lower physical fitness might need to exert themselves more intensely, resulting in higher %HRR[30].

Notably, the lactate threshold was attained at distinct levels for good and weak runners, reinforcing findings from studies that have measured lactate threshold based on blood lactate concentrations[31]. The interplay between high VO_2 max and increased lactate threshold could be attributed to heightened lactate accumulation in response to intensified glycogen metabolism through anaerobic mechanisms, subsequently disrupting the equilibrium between lactate production and elimination[31].

Mood analysis revealed runners' emotional responses towards their competitive performance. Our findings demonstrated a shift towards negative emotions and a decline in positive feelings, indicating a significant behavioral change influenced by mood. Such alterations in mood could be attributed to feelings of dissatisfaction and frustration when performance falls short of perceived potential. This aligns with prior work illustrating heightened depressive mood post-running due to self-assessment of inadequate preparation[32]. Higher exercise intensity often leads to increased fatigue, fostering negative emotions and diminishing sensations of calmness and vigor[33]. Furthermore, the link between mood outcomes and achievement of individual goals underscores how positive or negative mood can mirror success or failure.

Perceived exertion rates reported by runners before and after the sprint reflect their perception of work intensity. Our findings concur with previous research, showing elevated perceived exertion levels after the sprint, likely due to increased exercise intensity[34]. Moreover, perceived exertion has been correlated with elevated blood lactate concentrations, which aligns with our observations and indicates that feelings of exhaustion rise with escalating exercise intensity or duration.

Limitations of the Study

This study encountered limitations stemming from the scarcity of existing research on the subject matter. The challenge of finding relevant prior studies posed a hindrance to the comprehensiveness of the literature review. Additionally, gender-related limitations arose due to socio-cultural constraints, as female participation in endurance sports remains limited. Similarly, the selection of a specific age range for participants was necessitated by the availability of adequate data within that range.

Conclusion

The outcomes of this study illuminate the intricate influence of endurance exercise on various physiological and psychological facets. Notably, VO_2 max and lactate threshold (LT) emerged as robust indicators of running potential among male runners. Furthermore, an evaluation of runners' mood and perceived exertion before and after the sprint event revealed a notable increase in negative feelings and perceived exertion post-competition. This shift might be attributed to feelings of frustration or disappointment stemming from performance outcomes. It is worth noting that effective training interventions could potentially mitigate negative emotions, enhance mood, and alleviate perceived exertion, contributing to improved athletic performance.

Conflicts of Interest

The authors have no financial or non-financial interest with any organization.

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