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استجابات فسيولوجية للإجهاد الحراري وتأثيرها على الأداء الرياضي والوظائف الحيوية للجسم أثناء مباريات المصارعة الصيفية

Physiological Responses to Heat Stress and Its Effects on Athletic Performance and Vital Bodily Functions During Summer Wrestling Matches

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الملخص

أجريت هذه الدراسة لتقييم تأثير الإجهاد الحراري خلال المنافسات الصيفية على درجة حرارة الجسم الأساسية وضغط الدم ومعدل التنفس ومعدل التعرق لدى المصارعين في البيئات الحارة مقابل البيئات الحرارية المحايدة. تم إجراء قياسات فسيولوجية خلال نوبات قياسية مدتها 3 دقائق في كل حالة لـ 24 مصارعًا. ارتفعت درجة حرارة الجسم (بمتوسط 1.6 درجة مئوية)، وضغط الدم الانقباضي، وضغط الدم الانبساطي، ومعدل التنفس، وإجمالي فقدان العرق بشكل ملحوظ في الظروف الحارة مقارنة بدرجة حرارة الغرفة. تشير هذه النتائج إلى أن الإجهاد الحراري هو إجهاد كبير على القلب والأوعية الدموية وتنظيم الحرارة يمكن أن يضعف الأداء ويزيد من خطر الإصابة بأمراض الحرارة. يُظهر معدل التنفس المرتفع وفقدان العرق أن الجسم يريد التخلص من الحرارة، ولكنه في الوقت نفسه يشير إلى زيادة الإجهاد الفسيولوجي. تؤكد هذه النتائج على أهمية برامج التكيّف مع الحرارة وتوفير السوائل لتقليل مشاكل الأداء في الحرارة. بشكل عام، توفر هذه الدراسة معلومات قيمة عن الاستجابات الفسيولوجية على الأداء الرياضي للمصارعة تحت الضغط الحراري، والتي يمكن استخدامها كأساس لتحسين سلامة الرياضيين وتحسين أدائهم.

الكلمات المفتاحية: الإجهاد الحراري، درجة حرارة الجسم الأساسية، الاستجابة القلبية الوعائية، تنظيم الحرارة، أداء المصارعة

ABSTRACT

This study was conducted to evaluate the influences of heat stress (HS) during summer competition on core temperature, blood pressure, respiratory rate and sweat rate of wrestlers in hot versus thermoneutral environments. Physiological measurements were taken during 3-minute standardized bouts in each condition 24 male wrestlers. Core temperature (mean, 1.6 degrees C

higher), systolic blood pressure, diastolic blood pressure, respiratory rate, and total sweat loss increased significantly more in the hot condition compared with room temperature. These results suggest that heat stress is a significant cardiovascular and thermoregulatory stress that could impair performance and increase heat-illness risk. The high respiratory rate and sweat loss show that the body wants to get rid of heat, but at the same time indicate further increase of the physiological strain. These results emphasize the importance of heat acclimatization programmers and fluid provision to reduce performance problems in the heat. In general, the present investigation depicts valuable information on the Physiological Responses of wrestling under thermal strain, which can be used as the basis for the better athlete safety and performance management.

Keywords: Heat stress, core body temperature, cardiovascular response, thermoregulation, wrestling performance

Introduction

Heat stress causes an acute physiological challenge to combat sports athletes, especially in high-intensity sports including wrestling, where the thermoregulatory responsibilities are exacerbated by body-to-body combat, rapid weight reduction, and repeated anaerobic activities. When heat acclimated to high ambient temperatures, the body's core temperature rises more slowly (Cheuvront et al., 2010), compensatory responses are activated more readily (i.e., greater skin blood flow and sweat rate), and signs of physiological stress are reduced or minimized. Various interrelated physiological factors (e.g., cardiovascular strain, fluid electrolyte balance and cellular adaptations) are important contributors to the human response to exercise-heat stress (Sawka et al., 2011). Although these mechanisms are necessary to promote heat loss, they can also negatively affect cardiovascular stability and energy cost during prolonged exercise.

Wrestlers, who commonly use self-imposed dehydration to meet weight class regulations, are particularly susceptible to heat-related performance decrements. PLA diminishes plasma volume, impairs thermoregulation and raises core temperature in conditions of hyperthermia leading to an increased

physiological strain and heat illness risk (David, 2017; Miarka et al., 2020). Moreover, research has shown that in the presence of dehydration interval high-intensity wrestling bouts produce metabolic and cardiorespiratory system cumulative stress (e.g., elevated heart rate, lactate production and changes in blood pressure responses) (Jafari, 2021; Kraemer, 2001) .

Non-invasive physiological indicators, such as HR and sweat rate, have been shown to be good predictors of core temperature at thermal stress (particularly in outdoor endurance conditions) (Andrade et al., 2023). Tracking these measures is essential for the assessment of athlete safety and performance in hot conditions. Further, the effective intakes of fluids and cooling strategies have emphasized with performance measures and the prevention of heat illness (Bongers et al., 2017; McDermott et al., 2017). Sauna-induced hyperthermia is often used for acute weight cutting in wrestling and it also triggers unique hormonal and physiologic responses, including marked post-exposure suppression of cortisol, which contrasts with the elevation in stress response after physical exertion (Aggon et al., 2017).

Furthermore, the physiological demands of wrestling will demand more individualized training adaptations. Wrestling requires not only anaerobic muscular power, but also thermoregulation and cardiovascular conditioning under stress condition holds (Kraemer et al., 2004). As such, to objectively attempt to develop evidence-based training and hydration strategies it would be essential to clearly ascertain physical implications of the thermal response when performed in a live wrestling environment.

While high ambient temperatures are often linked to physiological strain during extended bouts of exercise, recent evidence suggests that also short-duration high-intensity activities -- such as 3-minute wrestling matches -- can greatly tax cardiovascular and thermoregulatory mechanisms. Continuous performance of bouts, especially with little rest between sets, increases the

thermal load and metabolic stress. In hot conditions, heart rate, core temperature and perceived exercise intensity can rapidly escalate during the short periods of an aerobic high-intensity repetitive bout (Nybo et al., 2014). Therefore, since these are limited in scope but high-intensity competitive events studying body responses during wrestling is still important for understanding the effect of heat stress on this sport.

Although the effects of heat stress on endurance and team sports are well-documented, only a few investigations have examined its influence in combat sports such as wrestling during actual competitive summer conditions. However, the majority of research has been conducted within laboratory settings using experimental protocols that may not fully reproduce the demands and exposure to heat during real wrestling competition. The absence of this applied, sport specific evidence makes it challenging for coaches, trainers and sports medicine practitioners to design precise hydration, acclimation or recovery protocols that are adapted to wrestling performance in hot climatic conditions. Thus, understanding of physiological responses to heat stress in wrestling during competition becomes pivotal for athlete safety and performance enhancement.

Thus, the purpose of this study was to assess the physiological load of wrestlers competing at different environmental temperatures. The main purpose is to monitor core temperature and blood pressure, respiration rate, sweat rate, and to compare and contrast these parameters at varying levels of thermal stress.

The objective of this study is to examine the how wrestlers respond physiologically competing in varying extremes of heat stress during summer conditions. The aim would be to determine the relationship between changes in core temperature, blood pressure, respiration rate and sweat rate are responsive during match play in varied ambient temperatures and their association with

performance. Moreover, the study will provide evidence-based guidelines for hydration, cooling and training practices that could improve athlete safety and performance in hot conditions.

The study hypothesises that: (1) core temperature significantly increases due to the ambient heat; (2) both systolic and diastolic blood pressure and respiratory rates are positively correlated with heat; (3) sweat rates increases in response to the heat as a compensatory thermoregulatory mechanism and finally (4) work capacity decrease with increasing heat stress. This study adds to our knowledge regarding the physiological requirements of wrestlers competing in hot conditions as well as potential applications to ensure safety and performance.

Materials and Methods

Study Design

The purpose of this study was to determine the response of wrestlers to combat in different thermal conditions. Conducted from June to July 2025 at an indoor sports hall in the College of Physical Education, Baghdad University. This design allowed controlled comparisons of core body temperature, blood pressure, breathing rate, and sweat rate between simulated summer heat conditions and thermoneutrality.

Participants

Twenty-four male wrestlers aged 18 to 22 years (mean ± SD = 19.8 ± 1.2) voluntarily participated. All wrestlers were classified as senior-level competitive athletes and we enrolled all eligible male senior wrestlers who were registered with first-division wrestling clubs in Baghdad, including Al-Quwa Al-Jawiya SC and Al-Shorta SC, into this study. All athletes were actively training at competitive levels and free from any cardiovascular, metabolic, or respiratory disorders as confirmed by pre-participation medical screening.

Procedure

On arrival to the testing facility, participants were given a brief explanation of the study's objectives and procedures and baseline hydration was evaluated by measurement of urine specific gravity (USG). Telemetric temperature capsules were ingested by the wrestlers 3 hours before the wrestling matches for the accurate assessment of core temperature during exercise. Following inclusion, participants were accommodated in a controlled environment to support the stabilization of physiology for test.

The experiments were performed under two different environmental conditions; outdoor during heat waves mimicking summertime temperatures and with temperatures ranging from 36 to 38°C and a relative humidity of 55–60%, and thermoneutral conditions (22–24°C, 40–45% relative humidity) indoor.

Experiments were performed over a series of selected days 1-June and 30-july 2025, timed around the hottest part of the day to guarantee exposure to closely similar high ambient temperatures. While the outdoor facility of the lab provides partial shading and natural air flow that, combined with Baghdad's temperatures in summers which usually range from 40 to 50 degrees Celsius during this time frame, allowed for testing sessions to take place at recorded temperatures varying between 36-38 °C. The environmental conditions were continuously monitored and confirmed to guarantee consistent heat stress exposure. The selected range of temperatures was intended to represent high but controllable thermal stress consistent with current safety recommendations, nontoxic exposure levels that could be safely monitored in humans. Values of temperature and humidity were recorded continuously, at mat level, discriminating among substrates adapting a SANAS certified digital thermo-hygrometer (Model ExTech 445580). In the outdoor heat-stress condition, testing was conducted at 12:00–15:00 in a cleared-air area without artificial cooling which ensures natural exposure to high ambient heat similar to

heatwaves typical of Baghdad summer. The experiment was replicated under a second thermoneutral condition in which matches were performed indoors at a well-ventilated sports hall equipped with evaporative cooling apparatus that maintained temperature approximately 22–24°C and moderate humidity. Environmental measures were obtained 5 min before and within 1 min after each bout to ascertain consistency of test conditions. Participants were randomly assigned to one of these conditions during the wrestling bouts.

The matches lasted three minutes each, adhering to the official United World Wrestling rules and with certified referees ensuring that they were competitive. During the break, 10 min, between bouts, participants rested passively by sitting down in a shaded environment to reduce the impact of the environment and achieve some enhancement of recovery at least.

Blood pressure and respiratory rate were recorded immediately before and after each bout with validated instruments. Nude body mass was measured before the first bout and immediately after the second bout for determination of sweat loss. No fluids were allowed during these recovery periods in order not to obfuscate end-hydration state and sweat rates. All physiologic measurements were made at the time of, or immediately following completion of, exercise for data integrity.

Volunteers were observed for heat related symptoms throughout the duration of testing and following the experimental protocol, exercise would be terminated if the increase in core temperature is excessive, cardiovascular instability was noted or discomfort expressed by participant. Nurses on-site were present to respond immediately when adverse events occurred.

This standardization induced synchronous and steady testing conditions and thus permitted robust data sampling, as well as better physiological response's comparison during wrestling effort.

Physiological Measurements

Core temperature was continuously monitored using telemetric capsules that subjects ingested (CorTemp™, HQ Inc., USA) 3 hours prior to testing to provide real-time feedback on body temperature as the test progressed-the capsules were purchased before the cut-off date and stored in accordance with suppliers instructions. You have to have the right kind of technology for measuring core body temperature during wrestling matches. The data were obtained by trained researchers, and all monitoring content was online real-time control (correctness&reliability) was carried out throughout the study. Adult's BP (systolic BP and diastolic) was measured in both before and after each bout instantly (Moench-Paturel et al., 2005) using an automated upper-arm digital sphygmomanometer (Omron M6 Comfort, Japan). Respiratory rate was manually determined by the counting of up-and-down movements produced by a slide caliper mounted around the thorax for 1 min before and after bouts, and later verified with a respiration monitor (Respironics Alice PDx). Sweat rate was estimated as the nude body mass loss (pre minus post bout) corrected for any fluid consumed during bouts, measured on calibrated digital scales (Seca 769, Germany).

Hydration Control

To reduce the confounding effect of hydration, subjects were instructed to ingest a sufficient amount of water over 24 hours before testing and avoid drinking caffeine and alcohol. Hydration status was determined by urine specific gravity (USG) using a portable refractometer and only athletes who presented with euhydration were included in the analysis.

Statistical Analysis

All statistical analyses were performed using SPSS software version 26 (IBM). Descriptive statistics, including means and standard deviation were calculated for all physiological measurements. For analysis, a repeated-

measures ANOVA was used to compare within-group and between-group conditions. Effect sizes were calculated using partial eta squared (η^2) to estimate the magnitude of observed effects. Statistical significance was accepted at $p < 0.05$.

Result

Table 1. Demographic and Anthropometric Characteristics of the Participants

Variable	Mean ± SD	Range
Age (years)	19.8 ± 1.2	18 – 22
Height (cm)	178.4 ± 6.5	165 – 190
Weight (kg)	75.3 ± 8.7	62 – 90
Wrestling Experience (years)	6.5 ± 2.1	3 – 10

Table 2. Core Body Temperature (°C) Before and After Wrestling Bouts Under Hot and Thermoneutral Conditions, Including Statistical Significance and Effect Size (Mean ± SD,)

Condition	Before Bout (°C)	After Bout (°C)	Change (Δ) (°C)	p-value	Effect Size
Hot Environment	37.1 ± 0.3	38.7 ± 0.4	1.6 ± 0.2	0.000*	0.78
Thermoneutral Environment	36.9 ± 0.2	37.4 ± 0.3	0.5 ± 0.1	0.015*	0.42
*Significant at $p < 0.05$					

Table 3. Systolic and Diastolic Blood Pressure (mmHg) Before and After Wrestling Bouts Under Hot and Thermoneutral Conditions (Mean ± SD)

Condition	Systolic Before	Systolic After	Diastolic Before	Diastolic After	p-value (Sys)	p-value (Dia)	Effect Size (Sys)	Effect Size (Dia)
Hot Environment	125 ± 8	138 ± 9	78 ± 6	85 ± 7	<0.001*	0.002*	0.65	0.41
Thermoneutral Environment	123 ± 7	130 ± 8	76 ± 5	79 ± 6	0.010*	0.050	0.32	0.18
*Significant at $p < 0.05$								

Table 4. Respiratory Rate (breaths per minute) Before and After Wrestling Bouts Under Hot and Thermoneutral Conditions

Condition	Before Bout	After Bout	Change (Δ)	p-value	Effect Size
Hot Environment	16 ± 2	28 ± 3	12 ± 2	0.000*	0.74
Thermoneutral Environment	15 ± 2	22 ± 3	7 ± 1	0.008*	0.38
*Significant at $p < 0.05$					

Table 5. Sweat Rate (kg) Estimated by Body Mass Loss Before and After Wrestling Bouts Under Hot and Thermoneutral Conditions (Mean ± SD, n = 24)

Condition	Pre-bout Body Mass (kg)	Post-bout Body Mass (kg)	Sweat Rate (kg)	p-value	Effect Size
Hot Environment	75.4 ± 8.6	73.6 ± 8.5	1.8 ± 0.3	0.000*	0.81
Thermoneutral Environment	75.2 ± 8.7	74.6 ± 8.6	0.6 ± 0.2	0.012*	0.35
*Significant at $p < 0.05$					

Discussion

In the present study, we investigated the physiological responses of wrestlers to heat stress while competing in summer and paid attention to core temperature (Tc), blood pressure (BP), respiration rate (RR) and sweat rate in both hot and thermoneutral conditions. Our findings indicated that core temperature, systolic and diastolic blood pressure, respiratory rate, and sweat rate were all significantly higher in the hot environment than during thermoneutral condition. These results are in accordance with previous research, demonstrating that it places the body under significant physiological stress resulting in the potential for both submaximal athletic performance and homeostasis to be compromised (Périard et al., 2022; Tyler et al., 2024).

The relatively large level of average esophageal hyperthermia (~1.6°C increase) observed during heat stress stands in stark contrast to that reported by Schlader et al. (2011), where they demonstrate that higher core temperature results in lower muscular endurance with "cognitive dysfunctio and diminished performance for athletes". These thermal effects occur with accompanying changes in the hemodynamic activity (HR, BP) as in our studies too. This is in line with prior work by Crandall & Gonzalez-Alonso (2010) who reported that the elevated cardiovascular demand during heat stress necessitates greater levels of cutaneous perfusion for thermal balance.

The increased respiration observed in the existing study under heat stress therefore also could be a counterbalancing effect to dissipate heat through respiratory exchange (Burdon et al., 2013). However, excessive ventilatory needs can lead to premature fatigue that prevents the athlete from holding intensities (Wells and Norris 2009). Furthermore, the increase in sweat rate under higher temperatures is linked to the body's principal thermoregulatory mechanism or response and dehydration is accelerated as well as an unfavourable electrolyte balance that may affect neuromuscular performance and thermoneutraity (Cheuvront & Kenefick, 2014).

These significant physiological responses also indicate that wrestling activities on regulation-sized mats induce considerable stress to homeostatic mechanisms and are likely to compromise performance with a concurrent increase in susceptibility to exertional heat illness. These results are in agreement with those from Périard et al. (2021) gave a suggestion for heat acclimation intervention and hydration strategy to mitigate the effects of degradative stress of excessive heat in combat sport athletes.

The current study adds specifically by indexing a variety of physiologic responses in actual, competitive work performance tasks, increasing ecological validity. Nonetheless, the sample was small, and because of an

absence of female wrestlers, our results may not be generalizable to females. Future studies should investigate additional biomarkers as they relate to systemic requirements of stress recovery and readiness, including sexual dimorphism, and other factors such as blood lactate and cortisol response to develop a more complete picture of the global stress response.

In summary the heat stress control is critically important to maintain functional capacity and performance during wrestling in hot conditions. Acclimatization and hydration to protect athletes' health and performance during heat stress are supplemented by coach- and sport-science level monitoring of a range of physiological responses.

Conclusions

high stress of heat load wrestling increases the body temperature (BT), arterial blood pressure (ABP), respiration and sweat among wrestlers during pre-competition stage, thereby causing a serious burden on athletes. These conditions may lead to impaired performance and greater susceptibility to heat illness. Thus, Athletic safety in high-temperature environments on training and competition days will depend on heat acclimation and hydration strategies that work! It is necessary to study larger numbers of general population and more physiological parameters, in order to increase our understanding about the correlation between heat stress and combat sports.

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