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The Relationship Between Cardiac Electrical Responses (ECG) and Maximal Voluntary Contraction After Full Wrestling Match Performance in Wrestlers

Ghazwan Kareem Khothier

ghazwan.kareem@qu.edu.iq

https://orcid.org/0000-0002-8121-5454

Al-Qadisiya University – Physical Education and Sport Sciences College

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ABSTRACT

Background: Wrestling is an intense exercise requiring significant demand on both cardiovascular and neuromuscular systems. Therefore, understanding how wrestling performance affects heart rate (ECG) and maximal voluntary contraction (MVC), as well as recovery of these systems post-match, is paramount to optimizing training loads and recovery protocols. **Procedures**: Six male wrestlers took to take part in the study. HR and MVC were assessed before, immediately after, and 30 minutes after the match. The heart rate was recorded with a 12-lead electrocardiograph and the MVC for both upper and lower limbs using a dynamometer hand-held. The data at each timepoint were compared using paired t-tests. **Results**: In the post-match time period, significant increases were observed in heart rate (from 72.5 ± 2.6 bpm to 160 ± 7.4 bpm), returning to baseline recordings within 30 min of rest (92.5 ±4.2 bpm). MVC fell from pre match 153.3 ± 9.8 Nm to post-match 126.7 ± 8.9 Nm and returned partially to 141.7 ± 10.5 Nm at minute +30 of rest) These changes are statistically significant, it is clear that wrestling takes a heavy toll on the body in terms of physical effort. **Conclusion**: A male competitive wrestler has a unique combination of cardiovascular and neuromuscular stress during matches. These can be rest and hydration, etc. that will help you to get recovered soon and perform better next time.

Introduction

Wrestling is probably one of the most physically demanding combat sports you can participate in, Effective physical training necessitates a comprehensive approach that incorporates not only cardiovascular exercise but also strength training, flexibility exercises, and neuromuscular conditioning to optimize performance and overall fitness, you also need massive muscular endurance. A full wrestling match is a high intensity physical effort, therefore all those different physiological responses where kind of more in high gear. The most recognizable manifestations of these physiological changes are in cardiac electrical responses (ECG) and neuromuscular force generation capacity, specifically maximal voluntary contraction (MVC). Conventional methods include evaluating cardiac electrical responses generally measured with electrocardiogram (ECG) which is limited on ambulatory, mal-exercise, and not specific to detect exercise-induced irregularities or stress [1]. For a peek at some of the cui bono bit, check out these responses to what might be issues involving CV stress in extreme sports. This technique has also been employed to accurately assess neuromuscular fatigue after anterior cruciate ligament rupture with subsequent ACL-reconstruction [2]. Nevertheless, the degree to such two important physiological variables are concurrently affected a prior wrestle match have had sparse research. Although the cardiovascular [1], [3] and muscular fatigue [4] consequences of intense exercise have been well documented previously, it has been poorly understood how these effects interact with ECG response to effort in wrestlers.

Although the literature has largely concentrated on cardiovascular adaptations to various forms of exercise [5], there is a paucity of research addressing responses to high-intensity sports such as wrestling. Traditionally, it is known that physical loading induces transitory modulation in the cardiovascular as well as the muscular systems [6] but these have not been extensively studied with respect to the integrated demands during wrestling. This relationship is critical in regards to sports performance and injury reduction for events such as combat sports. The role of serial ECG monitoring, well-established in sports for the detection of cardiac abnormality and recovery [7], has minimal application within wrestling. Additionally, the impact of wrestling on MVC and neuromuscular fatigue were previously addressed in isolated manners [4], with few references having detailed attention regarding its concomitant development [8].

Therefore, the aim of this study was to investigate the association between cardiac electrical responses (ECG) and maximal voluntary contraction (MVC) after a full wrestling match in order to fill this gap in research. The current study sought to examine the acute physiological responses to wrestling focusing on a sample of wrestlers from the Kazimiyah Club. To this end, it is critical to understand the cardiovascular and neuromuscular responses related to the physiological demands of wrestling in order to establish new strategies for training periods based on optimization of performance as well as recovery [9]. The results of this study will be useful to coaches, wrestlers and sports scientists who would learn about the key physiological outcomes that influence wrestling performance and recovery [10].

The aim of this study is to determine the effects of a full wrestling match on ECG responses and whether these changes correlate with depressions in MVC after performing such challenging

exercises. Results from this study will test the following hypotheses: (1) The vigorous intensity of effort required while wrestling will lead to notable alterations in ECG parameters, such as an increase in heart rate and perhaps certain abnormal ECG findings [5], [11] ; (2) Wrestlers MVC strength values will decrease temporarily immediately post-match due to neuromuscular fatigue [4]; and (3) There is a negative relationship between the ECG changes and reduction in MVC strength postmatch with increased cardiovascular stress potentially resulting in greater muscular fatigue levels towards the end of the match or recover time period [12].

It is important to take into account the relationship between these two physiological variables so that the performance of our wrestlers can be improved and at the same time risk of overtraining or injury decreased. In this study, the effects of wrestling apply on heart and muscle will be revealing some beneficial information to sport science, exercise physiology and athletic training.

Materials and Methods

Study Design

A within-subjects design of the study enabled every participant to act as their own control. All competitors wrestled 1 full wrestling match with data collection at time pre-match, immediately post-matc h and 30-min postmatch. This allowed direct comparisons of physiological responses between these time intervals, and our results with this approach furthered our understanding of cardiovascular and neuromuscular function during both the wrestling match and recovery from exertion.

Participants

The sample of the study included six male wrestlers belonging to Kazimiyah Club, their ages ranged from 20-25 years and they were practicing wrestling and participating in wrestling matches. The requirements for participation were at least 2 years of regular wrestling practice, no history of cardiovascular and/or neuromuscular diseases, or recent injuries that could affect maximal mechanical performance.

Data Collection

Cardiac electrical function was assessed by a hand-carried 12-lead electrocardiogram (ECG) device (CardioCare 2000, GE Health care). Chest electrodes were attached as per currently accepted 12-lead placement guidelines. The ECG equipment had been calibrated and initial measurements had been recorded before wrestling matches. ECG tracings were derived throughout the match period and extended by 5 min post-match for recovery assessments. Relevant parameters, such as HR, QRS duration and ST segment changes, were examined to evaluate the cardiovascular load.

To evaluate muscle strength in the upper and lower limbs, maximal voluntary contraction (MVC) was measured using a hand-held dynamometer (MicroFET 2, Hoggan Scientific, USA). Readings were taken at three time points: before the game, after the game and 30 min post-game. MVC

were assessed in the elbow flexor muscles and knee extensor muscles by a standardized procedure.

Participants were placed in their respective postures for accurate measurements. Elbow flexion muscles for the upper extremities were measured with the elbow joint in at 90 degree, forearm in a neutral position, elbow supported on stable table. For the lower extremities, knee extension strength was measured with the knee joint bent to 90° and the thigh/trunk stabilized to avoid compensatory movement. Subjects performed three maximal contraction trials for each limb with 3–5 seconds maximum force output during each trial, and a rest interval of 30–60 s to prevent fatigue. The largest value of the three trials was taken as the maximum voluntary contraction (MVC) for each leg.

Calibration of the dynamometer The dynamometer was calibrated before every test session for reliability. All measures were performed by a trained technician in an environment in which testes are likely to hang without variability due to influences from the outside.

Subjects wrestled full-contact competitive bouts within standard rules of the sport. The bout was fought in three 2 minutes rounds, with a 1-minute break between each round. The intensity of the game was well-controlled to reflect those demands imposed by real competition, resulting in physiological responses that were representative of those incurred during actual competitive matches.

The test conditions were highly controlled and held constant at a room temperature of 22 °C and humidity of 50%. Subjects were asked to refrain from vigorous physical exercise and alcohol consumption for at least 24 h before testing. They were also asked not to entertain large meals at least 2 hours before start of the testing session.

Procedure

On arrival at the testing site, participants received a detailed explanation of the procedures. ECG measurement at rest lasted 5 minutes and after that the assessment of unilateral max voluntary contractions (MVC) in upper and lower extremities was performed, by means of a hand-grip dynamometer. After the baseline data collection, a standardized warm-up (light aerobic exercise and dynamic stretching) was performed leading to a specific wrestling warm-up.

All the subjects later performed one full competitive wrestling match (3x 2-min of fight/1-min rest). Electrocardiogram (ECG) recordings of cardiovascular responses were obtained during the entire time of play. The gameplay intensity was adjusted to replicate the competition-level performance.

After the match, the athletes were allowed to rest seated for 5 min in wich ECG was recorded. MVC for upper and lower extremities was then measured. After a 30-min recovery period MVC force was measured again to assess the recovery from neuromuscular fatigue. Participants were

instructed to rest and refrain from performing any other physical exertion during the recovery phase.

Data Analysis

For data analysis, descriptive statistics will be used to summarize the ECG parameters (heart rate, QRS duration, ST segment changes) and MVC values at each time point. Paired t-tests will be conducted to compare the pre-match, post-match, and 30-minute post-match measurements for both ECG and MVC data. A significance level of $p < 0.05$ will be considered statistically significant. All analyses will be performed using SPSS software (Ver. 26).

Result

Table 1: Descriptive Statistics for Heart Rate (ECG) and Maximal Voluntary Contraction (MVC) at Different Time Points (Pre-Match, Post-Match, 30-Minute Post-Match)

Variable	Pre-Match (Mean ± SD)	Post-Match (Mean ± SD)	30-Minute Post-Match (Mean ± SD)
Heart Rate (bpm)	72.5 ± 2.6	160 ± 7.4	92.5 ± 4.2
Maximal Voluntary Contraction (MVC) (Nm)	153.3 ± 9.8	126.7 ± 8.9	141.7 ± 10.5

Table 2: Paired t-Test Comparisons Between Time Points for Heart Rate (ECG) and Maximal Voluntary Contraction (MVC)

Variable	Comparison	t-value	p-value
Heart Rate (ECG)	Pre-Match vs Post-Match	-41.90	0.000
	Pre-Match vs 30-Minute Post-Match	-18.80	0.000
	Post-Match vs 30-Minute Post-Match	49.63	0.000
Maximal Voluntary Contraction (MVC)	Pre-Match vs Post-Match	15.02	0.000
	Pre-Match vs 30-Minute Post-Match	4.74	0.005
	Post-Match vs 30-Minute Post-Match	-15.00	0.002

Table3: Summary of Data Changes (Percentage Change)

Variable	Comparison	Change (%)
Heart Rate (ECG)	Pre-Match vs Post-Match	123.25%
	Pre-Match vs 30-Minute Post-Match	29.06%
	Post-Match vs 30-Minute Post-Match	-42.19%
Maximal Voluntary Contraction (MVC)	Pre-Match vs Post-Match	-20.22%
	Pre-Match vs 30-Minute Post-Match	-9.54%
	Post-Match vs 30-Minute Post-Match	10.75%

Discussion

This study provides some useful information for sports scientist that surveyed the physiological modifications happening before and after a complete wrestling match, including heart rate (ECG) and maximal voluntary contraction (MVC). Our findings of the great deal of variation in heart rate and MVC across time points (pre-match, post-match and 30 minute post match) indicate marked changes in both cardiovascular and neuromuscular responses which corresponds to prior research on athletic performance during high-intensity exercise [13].

Increase in heart rate was significant from pre-match (72.5 ± 2.6 bpm) to post-match (160 ± 7.4 bpm) with % change of 123.25% (Table 3), indicating substantial cardiovascular strain during wrestling game operation. This is in line with research which illustrates a marked escalation in heart rate during intense physical exertion seen during combative sports [3], [11]. After 30 min resting, heart rate was reduced to 92.5 ± 4.2 bpm, which indicates the restoration of body healing mechanism and complies with similar findings from Laursen & Jenkins (2002) who found a reduction in HR after high intensity exercise in athletes in addition, the results of this study are in agreement with other studies that intensity of exercise significantly influences cardiovascular responses to exercise [14].

This finding is indeed supported by the marked difference in heart rate between pre-match and post-match ($t = -41.90$, $p = 0.000$); pre-match and 30 minute after match ($t = -18.80$, $p = 0.000$); as well as post-match and 30 min after match ($t = 49.63$, $p = 0.000$) (Table 2), showing that cardiovascular system suffers severe stress during wrestling activity but according to several previous studies, recovers very soon after cessation of exercise. This is in agreement with the U-shaped relationship between training intensity and cardiovascular loading that was observed by [15], the high-intensity sports require considerable cardiovascular effort, which diminishes to submaximal levels during recovery [16], [17].

The MVC was observed as a significant decrease of - 20.22% (as shown in table 3) whereas the mean pre-match and post-match MVC were found to be 153.3 ± 9.8Nm and 126.7 ±8.9Nm respectively. This decrease represents the muscle fatigue that resulted from a high-intensity exertion in a wrestling match as found by Carroll (2017), who showed decrease muscle strength

following intense physical activity. After 30 minutes of rest, there was a small improvement in the MVC decrease from 126.7 ± 8.9 Nm to 141.7 ± 10.5 Nm, with a recovery percentage of 10.75% (as shown in table3). This partial recovery is consistent with work showing that neuromuscular fatigue reverses completely within the initial minutes of exercise [18], [19].

Paired t-test results for MVC comparisons-match vs post-match ($t = 15.02$, $p = 0.000$) Post-match vs 30-Minute post-match ($t = -15.00$, $p = 0.002$) The traditional Intuitively shows a significant fatigue effect induced by wrestling activities on muscle behaviors. The comparison pre-match vs 30-minute post-match ($t = 4.74$, $p = 0.005$) showed a partial recovery of the muscle function within 30 minutes of rest as well; however, so did the difference main effects indicating that there is an interaction between those factors with no increase in performance directly after the match followed by a faster recovery. Also, in agreement with [20], which results were derived from the partial recovery of muscle strength up to 30 minutes after active rest protocols applied in high intensity sports.

The results emphasize the necessity to apply recovery strategies for wrestlers. The increase in heart rate was large and the fall of MVC substantial during wrestling matches indicating high physical impact. Recovery tags such as active rest, hydration and nutritional support should take precedence in the hierarchy of fatigue if the goal is to maximize recovery concurrently for cardiovascular and muscular systems by coaches atheletes. For example, the reports of Laursen and Jenkins (2002), Cipryan et al. (2017), and Fiorenza et al. (2019) demonstrated the recovery strategies might be effective in increasing cardiovascular and muscular endurance. In addition, knowledge of the temporal nature of maximal voluntary contraction (MVC) recovery responses may be beneficial for the development and prescription of training loads directed to reduce any injury risk as reported in [18], [21].

the results also demonstrate that hr recovery following exercise is a strong predictor of endurance performance and faster recoverers are more fit. This rule is also supported by the Laursen and Jenkins (2002) and Ferst and Chaitman (1984) studies that help explain which inferences can be drawn for cardiovascular adaptation and neuromuscular recovery relative to performance following each stimulus [5], [7].

Conclusion and Recommendations

This investigation clarifies the alterations of cardiovascular and neuromuscular mechanisms over wrestling actions while after them. Results Heart rate increased significantly after the match, normalizing within 30 min of recovery. In addition, MVC showed a significant rapid decrease at the end of the match, with an apparent partial recovery 30 min into the post-match rest period. These results indicate that wrestling is an intense, stressful sport which requires adequate recovery measures.

In order to facilitate optimal cardiovascular and muscular recovery, wrestlers should avoid passive rest; this article recommends that they instead use active rest in conjunction with hydration and other effective recovery strategies. Coaches should program recovery time into

training to reduce the overall fatigue and this will then lower injury risk. More studies are required to investigate the recovery trajectory over time and identify desirables practices for optimized performance and health in combat sports.

References

[1] M. Fiorenza *et al.*, "Neuromuscular fatigue and metabolism during high-intensity intermittent exercise," *Med Sci Sports Exerc*, vol. 51, no. 8, pp. 1642–1652, 2019.

[2] C. Foster *et al.*, "A new approach to monitoring exercise training," *The Journal of Strength & Conditioning Research*, vol. 15, no. 1, pp. 109–115, 2001.

[3] C. Schneider *et al.*, "Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription," *Front Physiol*, vol. 9, pp. 30–50, May 2018, doi: 10.3389/fphys.2018.00639.

[4] T. J. Carroll, J. L. Taylor, and S. C. Gandevia, "Recovery of central and peripheral neuromuscular fatigue after exercise," *J Appl Physiol*, vol. 122, no. 5, pp. 1068–1076, 2017.

[5] P. B. Laursen and D. G. Jenkins, "The scientific basis for high-intensity interval training," *Sports medicine*, vol. 32, no. 1, pp. 53–73, 2002.

[6] B. A. Franklin, "Cardiovascular responses to exercise and training," *Exercise and Sports Science. Philadelphia: Lippincott Williams & Wilkins*, pp. 107–116, 2000.

[7] J. A. Ferst and B. R. Chaitman, "The electrocardiogram and the athlete," *Sports Medicine*, vol. 1, no. 5, pp. 390–403, 1984.

[8] M. A. Wewege, D. Ahn, J. Yu, K. Liou, and A. Keech, "High-intensity interval training for patients with cardiovascular disease—is it safe? A systematic review," *J Am Heart Assoc*, vol. 7, no. 21, p. e009305, 2018.

[9] M. L. Eckstein *et al.*, "Physiological responses to combat sports in metabolic diseases: a systematic review," *J Clin Med*, vol. 11, no. 4, p. 1070, 2022.

[10] Ø. Rognmo *et al.*, "Cardiovascular risk of high-versus moderate-intensity aerobic exercise in coronary heart disease patients," *Circulation*, vol. 126, no. 12, pp. 1436–1440, 2012.

[11] V. L. G. Panissa, C. C. Cal Abad, U. F. Julio, L. V Andreato, and E. Franchini, "High-intensity intermittent exercise and its effects on heart rate variability and subsequent strength performance," *Front Physiol*, vol. 7, p. 81, 2016.

[12] T. D. Noakes, "Physiological models to understand exercise fatigue and the adaptations that predict or enhance athletic performance," *Scandinavian Journal of Medicine & Science in Sports: Review Article*, vol. 10, no. 3, pp. 123–145, 2000.

[13] L. Yaseen Abdulghani, M. Yaseen Abdulghani, and O. Waleed Abdulkareem, "Designing a palm pressure measurement device to improve motor coordination in

freestyle swimming among female students," *Journal of Physical Education and Sport*, vol. 25, no. 7, pp. 1506–1513, Jul. 2025, doi: 10.7752/jpes.2025.07168.

[14] L. Cipryan, G. Tschakert, and P. Hofmann, "Acute and post-exercise physiological responses to high-intensity interval training in endurance and sprint athletes," *J Sports Sci Med*, vol. 16, no. 2, p. 219, 2017.

[15] S. R. Hussain, A. Macaluso, and S. J. Pearson, "High-intensity interval training versus moderate-intensity continuous training in the prevention/management of cardiovascular disease," *Cardiol Rev*, vol. 24, no. 6, pp. 273–281, 2016.

[16] O. W. Abdulkareem and H. Sattar Jabbar, "Comparative Biomechanical Analysis of Three-Point Shooting Between Elite Iraqi Basketball Players and International Counterparts," *Journal of Sport Biomechanics*, 2025, doi: 10.61186/JSportBiomech.11.3.326.

[17] O. W. Abdulkareem, H. S. Jabbar, and A. J. Obaid, "The Effect of Soft Toss Machine Training on Some Kinematic Variables and backhand accuracy of Tennis Players U16 years.," *Journal of Physical Education (20736452)*, vol. 37, no. 1, pp. 190–205, Jan. 2025, doi: 10.37359/JOPE.V37(1)2025.2147.

[18] F. Imbach, N. Sutton-Charani, J. Montmain, R. Candau, and S. Perrey, "The use of fitness-fatigue models for sport performance modelling: conceptual issues and contributions from machine-learning," *Sports medicine-open*, vol. 8, no. 1, p. 29, 2022.

[19] M. B. Almeida and C. G. S. Araújo, "Effects of aerobic training on heart rate," *Revista Brasileira de Medicina do Esporte*, vol. 9, pp. 113–120, 2003.

[20] G. D. Barahona-Fuentes, Á. H. Ojeda, and D. Jerez-Mayorga, "Effects of different methods of strength training on indicators of muscle fatigue during and after strength training: A systematic review," *Motriz: Revista de Educação Física*, vol. 26, no. 03, p. e10200063, 2020.

[21] G. Lattier, G. Y. Millet, A. Martin, and V. Martin, "Fatigue and recovery after high-intensity exercise part I: neuromuscular fatigue," *Int J Sports Med*, vol. 25, no. 06, pp. 450–456, 2004.