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Research paper

Responses of Blood Lactate Concentration, Heart Rate, and Blood Pressure Using Three Active Recovery Methods Versus Passive Recovery After an Exhaustive Exercise in Young Elite Wrestlers

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Abstract

BACKGROUND: The recovery process should be optimized to enable performance capabilities as soon as possible.

METHODS: The main aim of this study was to determine the effects of three different recovery methods on heart rate (HR), blood pressure (BP), and blood lactate concentration (BLa) in young wrestlers after an exhausting intensive exercise. Sixteen cadet and junior elite freestyle wrestlers (mean ± SD: age: 17.44±1.15 years; 173.25±5.79 cm; BMI 22.1±1.68 kg/m^2; body mass 66.7±8.4 kg and 4.4±1.6 years of wrestling training experience) volunteered to participate in this study. The recovery protocols were performed in 4 consecutive weeks, using a counterbalance method. The active recovery session consisted of 15 minutes (1) jogging; 2) jogging and static stretching; 3) jogging and dynamic stretching) and 4) passive recovery among a control group. All data were reported as mean ± standard deviation (SD), with 95% confidence intervals (95%CI). The R- Pearson was calculated among variables. The statistical significance was considered P<0.05.

RESULTS: There were no significant differences among the three active and passive recovery methods for any of the dependent variables (p<0.05). All recovery methods have been equally effective at removing and restoring dependent variables to baseline in 15 minutes and none has had priority over others. Pearson correlation analysis revealed

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that there was no significant correlation between rate of perceived exertion (RPE) and selected physiological variables, except VO_{2max} in the jogging and dynamic stretch group. Although there was a significant correlation among physiological features (i.e., HR rest with exercise and BLa recovery); anthropometrical (i.e., BMI with BP recovery; hip circumference with BLa recovery) and performance variables (i.e., pull up test with BLa recovery; sit and reach test with BP exercise).
CONCLUSIONS: In summary, different recovery methods have shown similar responses to return to the baseline. It seems that some anthropometrical performance, and physiological features could be effective in recovery.

Keywords: Recovery, Blood lactate, Blood Pressure, Heart Rate, Wrestling

Introduction

Wrestling is a sport with several metabolic and physiologic demands (Kraemer et al., 2001; Horswill, 1992). Normally, up to four wrestling matches could take place for an athlete in a single day during a competition (Barbas et al., 2011). Elite athletes typically engage in high-intensity movements, and such exercises elicit increments in blood lactate (La) concentration and hydrogen ion concentration within the muscle, which is associated with muscle fatigue (Cairns, (2006). Due to increased La, body acid-base balance may be disrupted with each subsequent match in the tournament (Kraemer et al., 2001). This outcomes measurement represents an integral part of tests for anaerobic threshold determination and kinetics of lactate oxidation during the recovery of athletes (Karninčić et al., 2013). Besides, some other indicators of anaerobic metabolism such as biochemical markers during the event should be included to gain more clear insight into anaerobic mechanisms that occur during the competition in elite wrestlers (Drid, et al., 2016). Wrestlers must be able to buffer the high-acid muscle and La to demonstrate optimal strength and power during practice and competition (Kraemer et al., 2004). Thus, recovery protocols to reduce the fatigue caused by physical activities play a key role in success for athletes for the next match, related to the feeling of tiredness and an incapacity to train strenuously recognized by the trainers (Passelergue and Lac, 1999).
Anyway, fatigue reduction after matches requires a high level of recovery strategies that yield quick recovery, reduced the risk of injury, and performance improvement (Nédélec et al., 2013). In this sense, recovery from competition or training is dependent on the exercise, and it is thus essential to understand the specific mechanisms of fatigue and influences from external factors (Calleja-González et al., 2016). Furthermore, recovery methods should consequently be targeted against the major causes of fatigue (Nédélec et al., 2013). Maximizing recovery processes after a period of anaerobic exercise is extremely important especially when exercise is repeated (Ouergui et al., 2014; Monedero, 2000).

This is the main reason why the present study aimed to observe the amount of reversibility of the mentioned indexes after intense exhaustive exercise.

Accordingly, the recovery process in sports sciences is important when the athlete is forced to have two or additional matches in one day, which frequently happens in combat sports (Monedero, 2000; Franchini et al., 2003). Shorter recovery duration plays a decisive role in short-term high-intensity exercise in elite athletes (Harbili, 2015). However, all mentioned indexes cannot reach the baseline in post-exercise recovery at 15 min. The increase in physiological markers (e.g., hormonal changes, blood pressure (BP), blood lactate (BLa), and so on) indicated that bouts were development with high intensity, similar to other studies (Harbili, 2015; Franchini et al., 2013), and a study suggested that 15 minutes were not enough recovery time to get an athlete back to normal (Serrano-Huete et al., 2016). It should be noted that the interval between the two matches (according to the latest wrestling regulations >=20min) could not be dedicated to recovery so the wrestler spends a few minutes of the interval to get ready (warm-up) for the next match. Although achieving the results of a real wrestling match and other combat sports can provide more reliable data, the majority of coaches and wrestlers are not eager to participate in research processes during real matches. Lack of adequate recovery will affect the quality of the next match and performance (Calleja-González et al., 2016). Therefore, the lack of adequate recovery time would itself prevent the continuation of the recovery process, and to the best of our knowledge; no previous studies have been conducted on this topic mainly in wrestlers. Thus, the aim of the current study was to assess the effect of three active recovery methods vs. passive mode, after an exhaustive exercise. The changes in HR, BP, and removal rate of BLa were analyzed, and if there was a difference among these three active recovery methods in restoring mentioned indexes to the baseline, it would be investigated.

Methodology

a) Participants: The study participants were 16 provincial and national elite Wrestling Champions with at least 4 years of wrestling training experience, whose demographic data, medical and sports records were evaluated after the preliminary stages of the participant's selection and briefing meetings of familiarization to the study protocol for all of them or their parents. The participants were selected among volunteers who were free from any current orthopedic injury and had no major weight loss last month as well as had at least 4-5 years of wrestling training experience and the national championship. A written voluntary consent to participate was obtained from all wrestlers and their parents after informing them of the purpose of the experiment, procedures, and possible risk. According to this information, at the beginning of the study, none of the participants suffered from cardiovascular diseases. Wrestlers were asked to follow their diet according to instructions. Participants were instructed to avoid any exercise for at least 36 hours before the test days. Activities outside the test days were controlled as far as possible. The study was conducted according to the Declaration of Helsinki 2008 (actualization Fortaleza, 2013).

b) Instrument–tests: Seven-stage Bruce test (Robert, 2019) was used as an exhaustive exercise after preliminary warm-up each session by Technogym® (ITALY) treadmill. During the Bruce test, HR, BP, and ratings of perceived exertion (6 to 20) were collected (Borg, 1983). Skin thickness was measured from seven skinfolds by Lafayette caliper (Model 01128, USA). On the other hand, body density (BD) was estimated using the method of Jackson and Pollock (Jackson and Pollock, 2004). The BD was transformed to %BF by Brozek's equation (Brozek et al., 1963). The BP was measured by the Tanaka Sangyo manometer (Model 1160002). The HR was monitored telemetrically throughout all exercise protocols using a Polar HR monitor (AXN500). Blood samples (Plasma BLa) were analyzed by the Alfa classic auto-analyzer (Pars Azemon kit) in a laboratory.

c) Procedures: The research protocol was implemented in 4 consecutive weeks in winter (off-season), using counterbalance, and each testing session was held one week after the last former testing session. The different recovery protocol was performed by the same group (Repeated measure). The selected protocol was chosen using a combined method (Jogging and stretching) with a purposeful intensity (50 to 60 percent of maximum HR) for the highest effect as well as purposeful recovery time (3^{rd} and 15^{th} min) about specific circumstances of wrestling matches for 15 min. The groups were classified as follows: Group1: n=16 (3 min of passive, 12 min of jogging); Group 2: n=16 (3 min of passive, 6 min of jogging, 6 min of static stretch); Group3: n=16 (3 min of passive, 6 min of jogging, 6 min of dynamic stretch), and Group 4: n=16 sat on a chair for 15min as the control group. All three active recovery methods were followed by light-to-moderate static and dynamic general stretching (10s) for the large muscle group. The venous blood collection method was used to increase the accuracy of test results, which has priority compared to other common methods.

d) Research design: In this quasi-experimental study, the cluster and selective sampling methods were used.

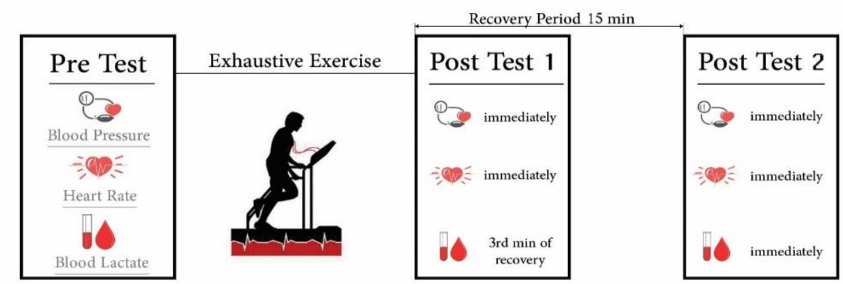

Figure1- Schematic Representation of the Research Design and Procedures

e) Statistical analysis: All data have been reported as mean ± standard deviation (SD) with 95% confidence intervals (95%CI). The Shapiro-Wilks (<50) test indicated normal distributions and consequently, parametric tests were performed. Equality of variances was checked by Levene's test. The data were analyzed through the one-way repeated measures ANOVA and Bonferroni post-hoc tests. Pearson correlation coefficient between rate of perceived exertion (RPE) with HR, BP and BLa was calculated. Effect sizes were calculated using partial eta squared (η_p^2), and Cohen's d values of 0.1, 0.3 and >0.5 were considered small, medium and large, respectively (Cohen, 1988). To detect between-group differences, the magnitude of Cohen's d effect sizes was calculated. The thresholds for Cohen's d effect size statistics were utilized as follows: trivial < 0.2; small= 0.01; moderate=0.6–1.2; large=1.2–2.0; very large=2.0–4.0; and extremely large= >4.0 (Batterham et al., 2006). All data analyses of the study were performed using SPSS® version 20. The level of significance was set at *p* <0.05.

Results

The means and standard deviation for indexes such as height, body mass, age, experience in wrestling, BMI, and VO_{2max}, and body fat of participants have been illustrated in table1.

Table 1- The Descriptive Data of the Sample

Body fat (%)	10.90±1.64
VO_{2max} (ml.kg^{-1}.min^{-1})	49.60±3.59
BMI (Kg/m^2)	22.14±1.68
Height (cm)	173.25±5.79
Body mass (kg)	66.71±8.49
Experience (years)	4.41±1.68
Age (year)	17.44±1.15
Index	Mean ± sd

The analysis proved that there were no significant differences in HR and BP among young wrestlers using active and passive recovery methods based on time interaction. There was only significant BLa in a group by time interaction ($p < 0.05$).

Table 2. Changes in BLa, HR and mean arterial BP between Three-time points for four recovery groups

Variable	Groups	Baseline	After exercise	After recovery	Main Effect of Time		Group x Time Effect		Group Effect	
		M±SD	M±SD	M±SD	p	d	p	d	p	d
Lactate (BLa)	JG	1.84±0.40	6.71±1.49	4.58±1.64	< 0.001*	0.860	0.020	0.116	0.018	0.154
	JG+ SS	1.84±0.40	7.13±1.71	4.51±1.72						
	JG + DS	1.84±0.40	6.96±2.11	4.62±1.23						
	PS	1.84±0.40	7.17±1.31	4.57±1.52						
Heart Rate (HR)	JG	68.31±6.64	198.38±9.94	115.06±10.76	< 0.001*	0.985	0.550	0.034	0.666	0.026
	JG+ SS	68.31±6.64	194.94±10.03	114.94±12.45						
	JG + DS	68.31±6.64	198.69±8.63	112.63±10.99						
	PS	68.31±6.64	195.44±8.04	109.75±11.19						
Blood Pressure (BP)	JG	87.60±9.80	96.10±10.02	75.31±8.95	< 0.001*	0.782	0.472	0.041	0.403	0.047
	JG+ SS	87.60±9.80	95.03±12.68	78.37±8.92						
	JG + DS	87.60±9.80	97.10±9.44	79.12±10.05						
	PS	87.60±9.80	102.15±9.86	76.67±8.91						

* Significance of the main effect in time ($p < 0.05$)
Abbreviations: Groups (recovery methods): JG= Jogging, JG+ SS= Jogging and static stretch, JG + DS= Jogging and dynamic stretch, PS=Passive

According to the table 3, BLa reveals main effects of time (F (2, 368.235) = 0.000), group x time effect (F (6, 2.625) = 0.020), and group effect (F (3, 3.633) = 0.018). Post-hoc tests using the Bonferroni correction indicated a significant decrease in BLa concentration compared to JG + SS vs. JG + DS and JG + DS vs. PS groups in the TPRE, respectively ($p = 0.05$ and $p = 0.01$, respectively, table 3).

Table 3- Changes in BLa, HR, and BP values between groups in three-time points

Variables	Groups Comparison	Mean Difference	95% Confidence Interval for Difference		Bonferroni	Cohen's
			Lower	Upper	P	D
TPBLLactate	JG vs. JG+ SS	< 0.001	-0.27	0.27	1	< 0.001
	JG vs. JG +DS	< 0.001	-0.27	0.27	1	< 0.001
	JG vs. PS	< 0.001	-0.27	0.27	1	< 0.001
	JG + SS vs. JG + DS	< 0.001	-0.27	0.27	1	< 0.001
	JG + SS vs. PS	< 0.001	-0.27	0.27	1	< 0.001
	JG + DS vs. PS	< 0.001	-0.27	0.27	1	< 0.001
TPEXLactate	JG vs. JG+ SS	-1.10875	-2.89	0.68	0.578	-0/62 M
	JG vs. JG +DS	-0.20188	-1.99	1.58	1	-0/11 T
	JG vs. PS	-0.93688	-2.72	0.85	0.951	-0/54 M
	JG + SS vs. JG + DS	0.90688	-0.88	2.69	1	0/46 M
	JG + SS vs. PS	0.17188	-1.61	1.96	1	0/09 T
	JG + DS vs. PS	-0.73500	-2.52	1.05	1	-0/38 M
PRE Lactate	JG vs. JG+ SS	-1.26313	-2.76	0.24	0.153	-0/71 M
	JG vs. JG +DS	0.55062	-0.95	2.05	1	0/45 M
	JG vs. PS	-1.33375	-2.83	0.17	0.112	-0/88 M
	JG + SS vs. JG + DS	1.81375*	0.3096	3.3179	0.010	1/13 M
	JG + SS vs. PS	-0.07062	-1.57	1.43	1	-0/04 T
	JG + DS vs. PS	-1.88437*	-3.3885	-0.3803	0.007	-1/43 L

Table 3- Changes in BLa, HR, and BP values between groups in three-time points

Variables	Groups Comparison	Mean Difference	95% Confidence Interval for Difference		Bonferroni	Cohen's
			Lower	Upper	P	D
TPBLHeart Rate	JG vs. JG+ SS	< 0.001	-6.41	6.41	1	< 0.001
	JG vs. JG +DS	< 0.001	-6.41	6.41	1	< 0.001
	JG vs. PS	< 0.001	-6.41	6.41	1	< 0.001
	JG + SS vs. JG + DS	< 0.001	-6.41	6.41	1	< 0.001
	JG + SS vs. PS	< 0.001	-6.41	6.41	1	< 0.001
	JG + DS vs. PS	< 0.001	-6.41	6.41	1	< 0.001
TPEX Heart Rate	JG vs. JG+ SS	3.4375	-5.439	12.314	1	0/34 S
	JG vs. JG +DS	-0.3125	-9.18	8.56	1	-0/03 T
	JG vs. PS	2.9375	-5.93	11.81	1	0/32 S
	JG + SS vs. JG + DS	-3.7500	-12.62	5.12	1	-0/40 S
	JG + SS vs. PS	-0.5000	-9.37	8.37	1	-0/06 T
	JG + DS vs. PS	3.2500	-5.62	12.12	1	0/39 S
TPRE Heart Rate	JG vs. JG+ SS	0.125	-10.84	11.09	1	0/01 T
	JG vs. JG +DS	2.438	-8.53	13.40	1	0/22 S
	JG vs. PS	5.313	-5.65	16.28	1	0/48 S
	JG + SS vs. JG + DS	2.313	-8.65	13.28	1	0/20 S
	JG + SS vs. PS	5.188	-5.78	16.15	1	0/44 S
	JG + DS vs. PS	2.875	-8.09	13.84	1	0/26 S

Table 3- Changes in BLa, HR, and BP values between groups in three-time points

Variables	Groups Comparison	Mean Difference	95% Confidence Interval for Difference		Bonferroni	Cohen's
			Lower	Upper	P	D
TPBL Blood pressure	JG vs. JG+ SS	< 0.001	-10.48	10.48	1	< 0.001
	JG vs. JG +DS	< 0.001	-10.48	10.48	1	< 0.001
	JG vs. PS	< 0.001	-10.48	10.48	1	< 0.001
	JG + SS vs. JG + DS	< 0.001	-10.48	10.48	1	< 0.001
	JG + SS vs. PS	< 0.001	-10.48	10.48	1	< 0.001
	JG + DS vs. PS	< 0.001	-10.48	10.48	1	< 0.001
TPEX Blood pressure	JG vs. JG+ SS	-0.0833	-13.88	13.71	1	-0/01 T
	JG vs. JG +DS	-4.5000	-18.30	9.30	1	-0/32 S
	JG vs. PS	-9.6667	-23.46	4.13	0.365	-0/70 M
	JG + SS vs. JG + DS	-4.4167	-18.21	9.38	1	-0/30 S
	JG + SS vs. PS	-9.5833	-23.38	4.21	0.378	-0/65 M
	JG + DS vs. PS	-5.1667	-18.96	8.63	1	-0/34 S
TPRE Blood pressure	JG vs. JG+ SS	-2.1250	-11.67	7.42	1	-0/21 S
	JG vs. JG +DS	-4.1250	-13.67	5.42	1	-0/38 S
	JG vs. PS	-2.4375	-11.98	7.11	1	-0/26 S
	JG + SS vs. JG + DS	-2.0000	-11.54	7.54	1	-0/19 S
	JG + SS vs. PS	-0.3125	-9.86	9.23	1	-0/04 T
	JG + DS vs. PS	1.6875	-7.86	11.23	1	0/17 S

Abbreviations: TPBL= Time Point Base Line, TPEX= Time Point Exercise TPRE= Time Point Recovery**;** JG= Jogging, JG+ SS= Jogging and static stretch, JG + DS= Jogging and dynamic stretch, PS=Passive; BLa: Blood Lactate, HR: Heart Rate, BP: Blood Pressure; T (Trivial); S (Small); M (Moderate); VL (Very Large); L (Large); EL (Extremely Large).

* Representing statistically significant differences in change between groups in time points, $p < 0.05$

Representing a significant difference between groups at the level of 0.05

Analysis of HR demonstrated main effects of time (F (1,4071.785), *p*<0.001), group x time effect (F (3,0.709), p=0.550), and group effect (F (3,0.526), *p*=0.666). Using a Bonferroni post-hoc test, the analysis proved that there was no significant difference in young wrestlers using active and passive recovery methods.

Analysis of the BP levels illustrated main effects of time (F (1, 215.450) = *p*<0.001), group x time effect (F (3, 0.850), *p*= 0.472), and group effect (F (3, 0.992) *p* = 0.403). Bonferroni post hoc test represented no significant difference in mean arterial BP among young wrestlers using active and passive recovery methods.

Table 5 shows the correlation coefficient between the RPE and selected physiological variables. No significant correlation was found among them, but a significant correlation was observed between RPE and VO_{2max} in the third group.

Table 5- Correlation between RPE and physiological variables

Correlations		HR exercise	HR recovery	BP exercise	BP recovery	BLa exercise	BLa recovery	VO_{2max} ml.kg^{-1}.min^{-1}
RPE	1	-0.308	0.105	0.007	0.022	-0.187	-0.167	-0.429
	2	-0.006	0.334	-0.041	-0.085	0.106	0.075	-0.484
	3	0.11	-0.186	-0.039	-0.178	0.164	0.204	-.552*
	4	0.303	0.363	-0.364	-0.049	0.307	0.43	-0.204

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

HR: Heart Rate, BP; Blood Pressure, BLa: Blood Lactate, recovery methods: 1. Jogging, 2. Jogging and static stretch, 3. Jogging and dynamic stretch, 4. sitting on a chair (control group).

Pearson correlation coefficient showed a significant correlation between physiological variables (BLa, HR, BP) and anthropometrical and performance variables. Moreover, the correlation coefficients were calculated for height, waist, arm circumferences, arm span, chest press, and squat with HR, BP, BLa after exercise, and recovery. The analysis showed that there was no significant correlation among them, so they were not reported in table 6.

Table 6- Correlation Coefficient Between Physiological Variables (BLa, HR, BP) and Anthropometrical and Performance Variables

Correlations	HR exercise	HR recovery	BP exercise	BP recovery	BLa exercise	BLa recovery
Body mass	-0.073	0.046	-0.013	0.278*	-0.138	-0.138
BMI	-0.066	0.099	0.006	0.275*	-0.197	-0.198
HR rest	0.323**	0.018	-0.147	-0.185	0.117	0.304*
Hip Circumference	-0.145	0.04	0.034	0.297*	-0.221	-0.289*
Sit and Reach	-0.151	-0.166	0.263*	0.073	-0.124	-0.069
Pull up	0.226	-0.276*	0.136	-0.098	.346**	.352**

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Discussion

The aim of this study was to compare the effect of three active recovery methods vs. passive mode after an exhaustive exercise. The results analyzed all changes in HR, BP, and removal rate of BLa as well as if there was a difference among these three active recovery methods in restoring mentioned indexes to the baseline, it would be investigated.

No significant difference between active and passive recovery methods was detected. Besides, there was no significant correlation between RPE and BLa, HR and BP.

Blood lactate: The Bla levels during intense training or competition have been used as an indicator of anaerobic power and capacity in wrestlers (Yoon, 2002), as well as for assessing levels of acidosis on activated musculature. (Karninčić et al., 2011). Further, BLa has been shown as a marker of fatigue and recovery (Modenedero 2009). Based on the results that emerged from the current study, the BLa increased following strenuous exercise (Bruce test) compared to rest time in all methods. Intermittent high-intensity sprint efforts combined with short recovery periods have been identified as a key factor in physical performance (Harbili, 2015). In the ongoing study, an increase in BLa concentration was found 3 min after exhaustive exercise (3^{rd}min of recovery) which was due to the secretion of lactic acid created in the muscle into the blood flow. The most common peak time of La was approximately 3-min post-exercise. In particular, VO_{2max} incremental exercise tests were performed while the peak of BLa could appear immediately after physical activity in the long-term average level (Viru, 2001). This is consistent with previous studies that have used a 3-min period for the evaluation of the BLa peak (Connolly et al., 2003; Dupont et al., 2003). In agreement with the findings of Bangsbo et al., and Connolly et al., (Bansgbo et al., 1994; Conolly et al. 2003), the present study revealed no statistically significant difference in BLa concentration among the active and passive protocols for periods up to 3min. Hence, active recovery seems to improve subsequent sprint performance, except in time to exhaustion when measured and/or recovery time is very short (Bishop & 2009), given that active recovery does not always improve performance when compared with passive recovery (Bond et al., 1991).

In addition, the analysis of blood samples (15^{th} min of the recovery period) exhibited that the level of Bla concentration was reduced more significantly compared to the 3^{rd} min in all groups. Despite this, there was no statistically significant difference between the three active and passive recovery methods. Hence, the studies by Coffey et al., (2004), Touguiha et al. (2011), and Dotan et al., (2011) are in line with the results of the present study. Furthermore, the current study focused on the effects of different types of recovery to remove BLa after maximal exercise, and based on previous Ferreira studies (2011), the La results suggested no difference among the three types of recovery in the 5^{th} min. In contrast, other studies in adults have demonstrated that an active recovery can enhance La removal in comparison with a passive recovery in a similar duration (Dotan et al., 2011). As a result, BLa at the end of active recovery was lower than passive recovery. Franchini et al. reported that active recovery resulted in higher BLa removal than passive recovery from 10 to 15 min post-exercise (Franchini et al., 2003). However, in terms of recovery duration, some studies suggested that when recovery duration was above 15min, there was no difference in improved performance between active recovery and passive recovery (Ouergui et al., 2014; Bansgbo et al., 1994). The time ratio between recovery and exercise is a key factor in repeated-sprint performance (Harbili, 2015). Nevertheless, some studies (Nedelec et al., 2013; Detanico et al., 2015) represented that when recovery duration was above 15 minutes, no difference was observed in improved performance between active and passive recovery. Future studies are needed to clarify this phenomenon in combat sports.

According to the findings of the ongoing study, the lactate kinetics was very close to its half-line in a cessation of the 15^{th} min of recovery. Thus, it seems that recovery methods for reducing BLa concentration have been effective in all methods. Therefore, the lack of significant difference among recovery groups in the present study implied that all methods were equally effective in removing and restoring BLa, and none of them had priority over another (Weltman et al., 1977). This could be due to the level of adaptation to exhaustive exercise and the capacity of young elite wrestlers in buffering and restoration of blood PH ion and lactate (Kraemer et al., 2001), given that previous studies have shown a significant relationship between increasing BLa concentration and HR (Branco et al., 2012). It also supports the concept that athletes with a low aerobic capacity exhibit a higher increase of Lactate at the same absolute load than those with a higher aerobic capacity (Withers, 1977; Canfield et al., 2013). Pearson correlation analysis revealed that there was no significant correlation between RPE and selected physiological variables (BLa, BP and HR). Only, there was a significant correlation between RPE and VO_{2max} in the third group (NAME THE GROUP HERE). The RPE scale is an effective method to quantify and monitor the intensity of the exercise (Soriano-Maldonado et al., 2014). This is primarily because of the strong association between RPE and heart rate, lactate, VO_2max, ventilatory thresholds, and respiratory rates (Utter et al., 2006).

Heart rate: Heart rate variability is considered as an index of HR autonomic control. During the immediate recovery after exercise, rapid alterations occur in cardiac function. The increase in parasympathetic activity, as well as a decrease in sympathetic activity, is known to occur after exercise **(**Savin et al., 1982; Pierpont et al., 2000). The HR showed a variation during the exercise and attained an average value of (198 bpm) in comparison to the average resting HR (68 bpm). This value was higher than the values reported by Barbas et al. (2010) in post wrestling match HR (184 bpm). Despite this, there were no significant differences between HRs_{max} for any parameters in this study. One potential explanation related to HR was registered after recovery (end of 15th min), and the HR values reduced significantly (115 bpm) in comparison to maximum HR. However, there were no significant differences between HR values in the three active and passive recovery methods (109 bpm). On the other hand, the cardiovascular responses in the present study were considerably higher than those in the studies of Kaikkonen et al., 2008 and Dupont et al., 2003. Besides, the HR post-recovery was slightly higher in the ongoing study than that in the studies of Ferreira et al. (95.7 bpm) 15thmin and (85.3 bpm) 30th min for the passive group (Ferreira et al., 2011), as well as Baraldi et al., 1991 (90-98 bpm) for cycling athletes (Baraldi et al., 1991). These differences between the present findings and others may be related to the different ages, intensity of exercise, and duration of recovery, and fitness level.

According to the results, there were no significant differences between the HR values of young wrestlers in three active recovery methods. Moreover, the results showed that young wrestlers could maintain maximum HR in high-intensity exercise. Moreover, a high level of heartbeat during passive recovery in adolescents accelerated blood circulating and lactate removal similar to active recovery. Therefore, elite wrestlers probably adapt to this type of stress by up-regulating various buffering reserves (Horswill, 1992). Pearson correlation coefficient revealed that there was no significant correlation between the RPE and BLa, HR and BP.

Blood pressure: Based on the findings, there was no significant difference among BP values of young wrestlers in three active and passive recovery methods. In comparison to exhaustive exercise, systolic BP decreased after exercise (166.81±19.17mmHg) versus (107.94±8.74 mmHg) after recovery, and diastolic BP decreased from (69.68±13.50 mmHg) to (61.06±7.11 mmHg). Also, mean arterial BP decreased from (102.15±9.86 mmHg) after exercise to (76.67±8.91 mmHg) in the cessation of passive recovery. In addition, that was lower compared to baseline (87.60±9.80 mmHg). These results were similar to the results of active recovery methods. It should also be noted that there was no significant difference between the training methods in the 15th min of the recovery, indicatingthe lack of superiority among the methods of the recovery protocol.

This studt is consistent with the studies of Forjaz et al. (1998) and Franklin et al. (1993), who reported that there was a significant decrease in BP which was lower compared to baseline (Forjaz et al., 1998; Franklin et al., 1993). However, Cornelissen et al. (2010) reported that in 3 conditions, systolic BP reduced significantly and reached a similar extent. Further, systolic BP during recovery was on average but not lower than at rest before exercise. In other words, the rate of BP was higher in the present study. In contrast, Pescatello et al. in 1991 found no BP fall after 30 min. Young elite wrestlers demonstrated a higher reduction in BP related to the dilation of the main arteries, leading to an increase in cardiac output. Halliwill et al. (1996) stated that there was a striking attenuation of the relationship between sympathetic activity and vascular resistance during recovery from exercise, indicating that an impairment in the transduction of nerve activity into vascular resistance contributes to post-exercise vasodilation. Previous studies showed that there was a direct, strong, independent, and continuous relationship between cardiovascular and BP. It has been established that the magnitude of neural and hemodynamic responses during exercise is directly related to exercise intensity (Cornelissen et al., 1993; Saito et al., 1993). Finally, there was no significant correlation between RPE with post-exercise BLa, HR, BP, and post-recovery values. However, the current study indicated a positive significant correlation among these physiological characteristics after exercise and recovery with some of the anthropometrical variables (Body mass, BMI, Hip circumference) and functional tests (Sit and Reach, Pull up). Based on the abovementioned research that focused on aerobic capacity, several studies have profiled other parameters of physical fitness such as flexibility, handgrip muscle strength, and vertical jump of judokas. It seems that strengthening anthropometrical indices can improve physiological characteristics. Additionally, correlation coefficients were calculated between height, waist, arm circumferences, arm span, chest press and squat with HR, BP, BLa after exercise and recovery. The analysis revealed that there was no significant correlation among them.

It is suggested that in the future research, different exercise intensities should be determined to distinct the recovery BP responses of participants with no history of cardiac arrhythmia and cardiovascular disease.

Pratical Applications

Based on the present results, practitioners could choose up any of our employed methods to properly recover the athletes since there was no between-group difference.

Recommendations for Future Research

1) Future research should focus on other indicators and biomarkers such as muscular injuries, delayed onset of muscle soreness, oxidative stress and immunological factors in wrestling competition.
2) Further studies should be conducted on a single-day wrestling tournament where several matches are held in one day to evaluate the drop of athlete performance from the first to the latest wrestling.

Conclusion

It could be concluded that passive recovery is more suitable for teenage wrestlers than active recovery within 15 minutes.

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Conflict of Interest Statement

The authors declared no conflict of interest.

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Ethical Approval information

Ethics Committee approved the present study with the code of IR.SSRC.REC.1399.117.

Data Sharing Statement

No data sharing statement was established.

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