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ORIGINAL ARTICLE

Effects of Recovery Type after a Kickboxing Match on Blood Lactate and Performance in Anaerobic Tests

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Abstract

Purpose: **To verify whether active recovery (AR) applied after a kickboxing match resulted in better performance in anaerobic tests when compared to passive recovery (PR).**

Methods: **Eighteen kickboxers volunteered to participate on a Kickboxing match preceded and followed by anaerobic tests: squat jump (SJ), the counter movement jump (CMJ) and the upper-body Wingate test. Blood lactate (BL), heart rate (HR) and rate of perceived exertion (RPE) were analyzed before and after rounds. The recovery sessions consisted of 10min at 50% of maximal aerobic speed or PR. BL was measured at 3, 5 and 10 min after the match, while HR, RPE and anaerobic power were assessed after the recovery period.**

Results: **BL, HR and RPE increased significantly (P<0.001) during the match. BL was lower (P<0.001) after AR compared to PR at 5 min and 10 min (e.g. AR: 8.94 ± 0.31 mmol.l^{-1}, PR: 10.98 ± 0.33 mmol.l^{-1}). However, PR resulted in higher (P<0.05) upper-body mean power (4.65 ± 0.5 W.kg^{-1}) compared to AR (4.09 ± 0.5 W.kg^{-1}), while SJ and CMJ were not affected by the recovery type.**

Conclusion: **The lactate removal was improved with AR when compared with PR, but AR did not improve subsequent performance.**

Key Words: Contact Sports; Athletes; Performance; Blood Lactate; Kickboxing; Performance Recovery

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INTRODUCTION

Kickboxing is a combat sport that requires complex skills and tactical excellence for success [1,2] with a typical match consisting 3 rounds of 2 minutes each with a rest of 1 minute between rounds [3].

The recovery process in sport has importance when the athlete may have to compete on more than one occasion during a competition held in a single day, which happens in many sports [4]. The influence of recovery type on subsequent performances has not received consensus in the literature. Several authors [4,5] have reported better performances when active recovery (AR) was applied. However, AR does not always improve performance when compared with passive recovery (PR)[6] and authors found that performance was improved when PR was introduced between high-intensity exercise rather than AR [7].

For recovery periods around 10–20 min, some studies have indicated that AR is better than PR for blood lactate removal [8-10], however its effects on subsequent performance are controversial when the time interval between the first and the second bout is the same[4,6,10,11].

Specifically with combat sports, only two studies manipulated the recovery process after combat simulation [12,13]. Two other studies [14,15] measured blood lactate concentration after combat sports specific tasks. Hemmings et al [14] compared massage with PR in a boxing-specific task and found decreased performance in the second bout of boxing on a specific dynamometer, but no performance difference was found after massage compared to PR. Touguinha et al [15] found no difference in blood lactate concentration after 9 min of AR or PR, when judo athletes were submitted to a *uchi-komi* (technique repetition) task performed at a fixed intensity until fatigue. Both studies with judo combat simulations [12,13] reported faster blood lactate removal after AR compared to PR, using 15 min interval. However, there was no significant difference in a non-specific anaerobic task (4 upper-body (Wingate tests) after AR or PR [13], although the second study [12] indicated that the 15 min period was long enough to restore performance to basal level in both non-specific and specific judo tests. No study using a striking combat sport (e.g. boxing, kickboxing, taekwondo) match simulation was found. Thus, the aim of our study was to compare the effects of AR and PR conducted after a kickboxing match on anaerobic performance.

METHODS AND SUBJECTS

Experimental approach:

The recovery process is important when athletes are called to compete twice or many times in a single day like in many combat sports (e.g. judo, boxing) [12,14]. Kickboxing competitions can lead athletes to compete more than one match per day [World Association of Kickboxing Organizations (WAKO), 2012]. Thus, the recovery process between matches and its effect on subsequent performance is important to optimize a kickboxer's physical ability.

For this end, the protocol design of our study was as follows: kick boxers were evaluated before and 10 min after kickboxing match simulation. Heart rate (HR), blood lactate (BL), performances for lower body power tests (squat jump–SJ-and counter movement jump test-CMJ) and upper-body power (Wingate test) were assessed, because the performance during the match is affected by many aspects and it would be difficult to determine the influence of AR or PR on it.

Subjects:

Eighteen male kick boxers were recruited from a local sporting club to participate in this study. The mean (± standard deviation) age, height and weight were 18.5±1.85 years, 174.4±7.7 cm and 63.2±9.1 kg, respectively. They were exercising for five days a week for 2 h per day. Participants in the study were at least a black belt (first Dan) kick boxer with an experience in this sport for 8.2±0.9 years. They participated regularly at least for 2 years in official kickboxing competitions before the study. The study was conducted in the specific phase of preparation for the Tunisian Kickboxing Championship.

After receiving a thorough explanation of the protocol, they gave written consent to participate in this study. The study was conducted according to the Declaration of Helsinki and the protocol was fully approved by the University Ethics committee before the commencement of the assessments.

Procedures:

Fig. 1 presents a schematic description of the study design. With the aim to eliminate any effect of gender only male subjects were recruited and all assessments were performed at the same time of day to reduce the effect of any diurnal variation on muscle performance.

One week before the assessments, the athletes were familiarized with the experimental procedures. They were instructed on the proper use of Borg's Category Scale for rating of perceived exertion ranging from 6 to 20. Blood lactate concentration was measured using a Lactate Monitor (Lactate Pro, Arkray, Japan) [16] and heart rate was monitored through a heart rate monitor (Vantage s620, Polar, Finland).

Upon arrival at the gymnasium and after 10-minute seated rest, BL concentration and HR were measured.

Before tests, participants performed a 5 min warm-up protocol consisting of submaximal running, active stretching, and jumping exercises [17]. For the upper body, the warm-up included 10 min of low to moderate intensity, pedaling at 50 to 60 rpm, interspersed by four or five all-out sprints of 4-s to 6-s duration. Warm-up

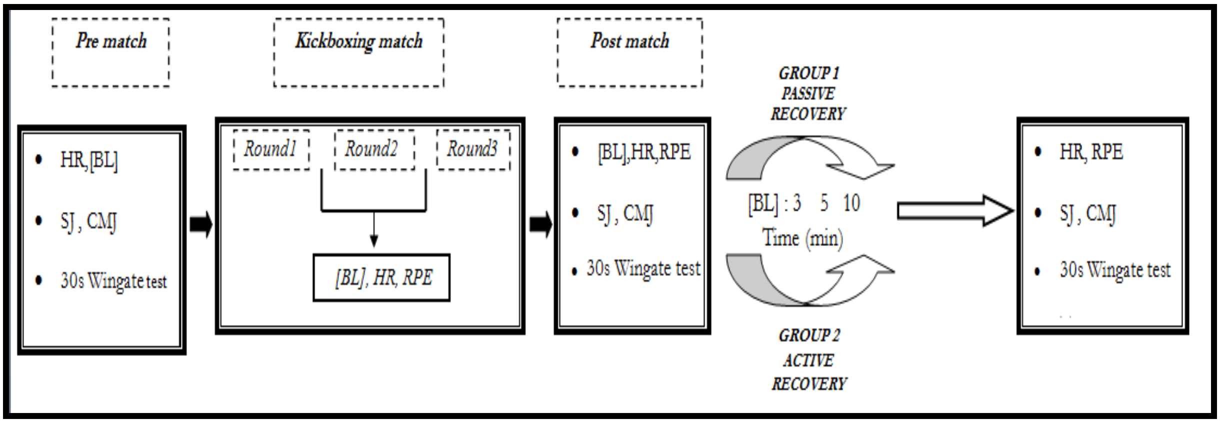

Fig. 1: Schematic representation of the study design and procedures.

HR: heart rate; [BL]: blood lactate measurements: squat jump; CMJ: Counter movement jump; RPE: rating of perceived exertion score

was followed by 3 min rest before the testing. After that, kickboxers performed SJ, CMJ and the upper-body Wingate test. Tests were executed with interval of 3 minutes between them. For the match session, athletes were paired according to rules of the WAKO.

All participants did not present any health restriction and fights were carried in a safe way, in an official ring (8 m x 8 m) with the presence of a national central referee.

The match consisted of three 2-minute rounds separated by 1-minute seated recovery and athletes were instructed to strike with full power and speed. During the match, HR, BL and rating of perceived exertion score (RPE) were measured after each round. The RPE was obtained at the same moment that BL was being measured. At the end of the match, the athletes performed another set of the anaerobic tests. The last session of the protocol design was reserved for the recovery procedure; subjects performed 10 minutes of AR protocol or PR protocol. For the PR, athletes remained seated on a chair. The AR group realized 10 min of run on a treadmill at 50% of maximal aerobic speed (MAS) predetermined using the YO-YO test level I which consists of repeated 2×20m runs back and forth between the starting, turning, and finishing line at a progressively increased speed controlled by audio bleeps from a tape recorder .Between each running bout, the subjects have a 10-s active rest period, consisting of 2×5 m of jogging. When the subjects twice have failed to reach the finishing line in time, the distance covered is recorded and represents the test result [18]. It consists of 4 running bouts at 10–13 km·h^{-1} (0-160 m) and another 7 runs at 13.5–14 km·h^{-1} (160-440 m), where after it continues with stepwise 0.5 km·h^{-1} speed increments after every 8 running bouts (i.e. after 760, 1080, 1400, 1720 m, etc.) until exhaustion [18].

The choice of recovery intensity (i.e. 50% MAS) was to verify if our results will go with the assertion of Dorado et al [5] which indicated that when the intensity of the active recovery is relatively high (i.e. 50% of maximal aerobic speed), active recovery would fail to show beneficial effects on subsequent performance.

BL was measured at 3, 5 and 10 minutes, HR and RPE were obtained after the recovery procedure.

At the end of the recovery period, athletes were submitted to the same anaerobic tests again.

Squat jump test (SJ):

For the SJ, the subjects were instructed to start from a static position of 90° at the knee angle. Prior to the jump the position was controlled with a manual goniometer. During the jumps, hands were kept on the hips. Three maximal SJ were performed with 1 min interval in-between and the best performance trial was used for the subsequent statistical analysis.

Countermovement Jump (CMJ):

During the CMJ, the subject was instructed to rest his hands on his hips while performing a downward movement followed by a maximal effort vertical jump. All subjects were instructed to land in an upright position and to bend the knees following landing. Three trials were completed, and the best performance trial was used for the subsequent statistical analysis. The SJ and CMJ tests were performed using an infrared jump system (Optojump, Microgate, Bolzano, Italy) interfaced with a microcomputer.

Upper-body Wingate test:

Kickboxers completed one bout of the upper-body Wingate test. Load was set at 4.9 N.kg^{-1} of body mass [12]. Peak power, mean power, fatigue index were calculated as previously reported [12]. The test was performed on a Monark model 894[E] (Monark AB, Varberg, Sweden).

Statistical Analysis:

All statistical tests were processed using SPSS 13.0 software. Mean and standard deviation (SD) were calculated for the selected variables. The Shapiro-Wilk *W*-test of normality revealed that the data were normally distributed. Once the assumption of normality was confirmed, parametric tests were performed. Mauchly test of sphecirity was used to verify compound symmetry and the Greenhouse-Geisser correction was used when necessary. Data of the Wingate test, CMJ, and SJ performances and values of HR, blood lactate, and RPE were analyzed using a two-way (recovery group and moment of measurement) analysis of variance with repeated measures in the second factor. When appropriate, significant differences between means were assessed using the Bonferroni test. Effect sizes were calculated for all variables using eta squared. The following scale was used for the interpretation of the effect size: [trivial]: <0.2, [trivial]; 0.2–0.6, [small]; 0.6–1.2, [moderate]; 1.2–2.0, [large]; and >2.0, [very large] [19]. The probability level accepted for statistical significance was set at $P<0.05$.

RESULTS

Performances:

Results from the SJ, CMJ tests and 30s Wingate test before, after the match and after the recovery procedure are displayed in Table 1.

For the SJ there was a moment effect ($F_{2,\ 32}=6.8$; $P=0.004$; $\eta^2=0.30$), with lower values after match compared to values at rest ($P=0.004$) and after recovery protocols ($P=0.02$). For the CMJ there was also a moment effect ($F_{2,\ 32}=25.4$; $P<0.001$; $\eta^2=0.61$), with higher values before match compared to values after match ($P<0.001$) and after recovery protocols ($P=0.009$), while values after match were lower than after recovery protocols ($P=0.001$).

For peak power (PP) there was an effect of moment ($F_{2,\ 32}=12.8$; $P<0.001$; $\eta^2=0.45$), with higher values before the match compared to the end of the match

Table 1: Muscle performances [mean (standard deviation)] on the Wingate test (i.e. PP, MP, FI) and on the vertical jumps test (i.e., SJ, CMJ) recorded before, after kick boxing match and after active and passive recoveries in youth kick boxers

Variable	Active recovery (n=9)			Passive recovery (n=9)		
	At rest	After match	After AR	At rest	After match	After AR
SJ (cm)*	27.92 (3.84)	24.80 (4.12)	27.66 (4.28)	28.86 (4.54)	25.51 (3.34)	27.81 (3.46)
CMJ (cm)‡	29.80 (5.33)	27.23 (4.3)	29.00 (5.34)	30.89 (2.93)	27.79 (3.62)	29.09 (3.59)
PP (W.kg^{-1})*	5.85 (0.83)	5.05 (0.78)	5.58 (0.6)	5.93 (0.52)	5.35 (0.36)	5.88 (0.75)
MP (W.kg^{-1})δ	4.56 (0.56)	4.00 (0.51)[a]	4.09 (0.5)[b]	4.45 (0.48)	4.25 (0.44)	4.65 (0.50)
FI (%)δ	46 (6)[c]	43 (11)[d]	54 (2)	56 (1)	48 (13)	45 (8)[e]

* Moment effect ($P<0.05$), values after match different from rest and after recovery protocols; ‡ Moment effect ($P<0.001$), values before match different from after match and after recovery protocols, values after match different from after recovery protocols; δ interaction effect ($P<0.05$). [a] different from AR before match ($P<0.05$) and PR group after 10 min of recovery ($P<0.01$). [b] different from PR group 10 min after match ($P<0.05$); δ Interaction effect ($P<0.05$). [c] AR group at different from PR group at the same moment ($P<0.05$); [d] AR after match different from AR group after 10 min of recovery ($P<0.05$) and PR group at rest ($P<0.01$); [e] PR group after recovery different from PR group at rest condition ($P<0.01$) and AR group after 10 min of recovery ($P<0.05$).
SJ: squat jump; CMJ: countermovement jump; PP: peak power; MP: mean power; FI: fatigue index.

(P<0.001) and after the recovery process (P=0.002). An interaction effect was found for mean power (MP) ($F_{2, 32}$=4.4; P=0.021; η^2=0.27). Values after match in the AR group were lower compared to before match in the same group (P=0.01) and PR group after 10 min of recovery (P=0.003). The AR group also presented lower values (P=0.01) 10 min after match compared to PR group in the same moment. An interaction effect was found for the FI ($F_{2, 32}$=11.1; P<0.001; η^2=0.20). AR group had higher FI at rest compared to PR group at the same moment (P=0.025), and AR group presented a lower FI in the Wingate test performed after match compared to both AR group after 10 min of recovery (P=0.01) and PR group at rest (P=0.002). PR group after recovery presented lower fatigue index (FI) compared to both PR group at rest (P=0.006) and AR group after 10 min of recovery (P=0.002).

Rating of perceived exertion:

Table 2 presents the RPE reported by both groups after each round of the kickboxing match and after the recovery processes.

There was an interaction effect for RPE ($F_{3, 48}$=3.9; P=0.014; η^2=0.95). RPE after round 1 for the AR group was lower than that after rounds 2 and 3 for both groups, but higher than that after 10-min recovery of the PR group (P<0.001 for all comparisons). In a similar way, RPE after round 1 for PR group was lower than that after rounds 2 and 3 for both groups, but higher than that after 10-min recovery of the PR group (P<0.001 for all comparisons). RPE after round 2 of the AR group was lower than that after round 3 for both AR (P=0.023) and PR groups (P=0.004), and higher than that after 10-min of recovery for both groups (P<0.001 for both comparisons). RPE after round 2 for PR group was lower than that after round 3 in the same group (P=0.01), and higher than that after 10-min of recovery for both groups (P<0.001 for both comparisons). RPE after round 3 for both groups was higher than that after 10-min recovery in both groups (P<0.001 for all comparisons). Finally, RPE after the recovery process for the AR group was lower from which reported by the PR after round 2 (P<0.001), but higher than that after 10-min of recovery for the PR group (P=0.02).

Heart rate:

Table 3 presents heart rate values during each round of the kickboxing match and after 10-min recovery processes.

There was an interaction effect for heart rate ($F_{6, 96}$=99.7; P<0.001; η^2=0.95). During the recovery process, there was a difference between AR and PR at 10-min of recovery (P<0.001). Additionally, the only moments with no difference were between: round 1 of the AR group and before round 3 for both groups; before round 2 for the AR group and after 10-min of recovery for the same group; before round 3 for AR group and round 1 of the PR group; after 10-min of recovery for the AR group and before round 2 for the PR group; round 1 of the PR group and before round 3 for the same group. All other points differed from all others (P<0.001).

Blood lactate:

Table 4 presents blood lactate values before the kickboxing match, after each round and during the recovery processes.

Table 2: Mean scores of RPE (6-20 scale) after each round during the match and after recoveries

Time	Active recovery group (n=9) Mean (SD)	Passive recovery group (n=9) Mean (SD)
After Round 1	12 (1)[a]	11 (1)[b]
After Round 2	14 (2)[c]	14 (2)[d]
After Round 3	16 (2)[e]	16 (2)[e]
After 10-min recovery	11 (1)[f]	9 (1)

SD: standard deviation; a: different from AR rounds 2 and 3, PR rounds 2, 3 and after 10-min of recovery (P<0.001); b: different from AR rounds 2 and 3, PR rounds 2, 3 and after 10-min of recovery (P<0.001); c: different from AR and PR round 3 and after 10-min recovery (P<0.05); d: different from PR round 3 and AR and PR after 10-min of recovery(P<0.05); e: different from AR and PR after 10-min of recovery (P<0.001); f: different from PR after round 2 and after 10-min recovery.

Table 3: Mean heart rate values during kickboxing match and after recoveries

Variable	Active recovery (n=9) Mean (SD)	Passive recovery (n=9) Mean (SD)
Rest (bpm)	71(3)	69(5)
Round 1 (bpm)	141(3)	142(3)
Before round 2 (bpm)	139(3)	141(3)
Round 2 (bpm)	163(4)	166(3)
Before round 3 (bpm)	141(47)	142(4)
Round 3 (bpm)	180(5)	182(4)
After recovery (bpm)	136(5)	93(5)

SD: standard deviation; Interaction effect (P<0.001). No difference was found between AR and PR groups when the moment was considered, except by the difference between AR and PR in the same moment was found at 10-min of recovery; no difference were between: round 1 of the AR group and before round 3 for both groups; before round 2 for the AR group and after 10-min of recovery for the same group; before round 3 for AR group and round 1 of the PR group; after 10-min of recovery for the AR group and before round 2 for the PR group; round 1 of the PR group and before round 3 for the same group. All other points differed from all others.

There was an interaction effect for blood lactate ($F_{6, 96}$=8.9; P<0.001; η^2=0.36). Blood lactate increased across rounds, peaked at 3 min after the last round and started to decrease, independently of group. Significant differences between groups at the same moment of measurement occurred only at 5 and 10 min after the last round, with higher values (P=0.03 and P<0.001, respectively) in the PR group compared to AR one.

DISCUSSION

The purpose of this study was to assess the effects of recovery type (active versus passive recovery) on performance in anaerobic tests applied after a full contact kickboxing match.

The main finding of the present study was that only values of MP were significantly higher and FI was lower when PR was applied compared to AR. RPE scores, values of HR and blood lactate increased for both PR and AR groups during the match and significant higher values of RPE and HR were found when AR was applied compared to values obtained after PR. AR resulted in faster lactate removal at 5 and 10 min.

Results of the present study showed that performance in SJ and CMJ decreased after the match. This decrease could be explained by the fact that kickboxers are called to strike with full power and that kickboxing competitions need special types of

Table 4: Mean blood lactate values before and during a kickboxing match and after active and passive recoveries

Variable	Active recovery group (n=9) Mean (SD)	Passive recovery group (n=9) Mean (SD)
Rest (mmol.l^{-1})	0.95(0.31)	0.97(0.42)
Round 1 (mmol.l^{-1})	8.63(0.87)	8.82(0.73)
Round 2 (mmol.l^{-1})	11.72(0.85)	11.75(0.92)
Round 3 (mmol.l^{-1})	14.93(0.71)	14.87(0.69)
3 min after (mmol.l^{-1})	13.24(0.39)	14.01(0.32)
5 min after (mmol.l^{-1})	11.99(0.40)[a]	13.00(0.20)
10 min after (mmol.l^{-1})	8.94(0.31)[b]	10.98(0.33)

SD: standard deviation**;** Interaction effect (P<0.001). Blood lactate increased from rest to the end of round 3, peaked at 3 min and decreased thereafter, independently of recovery group. Groups differed in the same moment of measurement only at (a) 5 min (P=0.03) and at (b) 10 min (P<0.001).

movements which are evaluated by velocity, and strength similar to some other sports (i.e. Kung-fu) [20]. Moreover, kickboxers generally use jumping techniques to strike the opponent and displacements which can be characterized by plyometric phases. In this context, Allen et al [21] have reported that muscles being used intensively show a progressive decline of performance.

Likewise, the performance decrease in the Wingate test after the match could be explained by the great anaerobic solicitation and the types of movements that were ensured with recruitment of fast fibers, which can be the cause of decrease of performance in the Wingate test by the fact that fatigue is more pronounced in these fibers [21].

Otherwise, RPE scores increased during the match and reached a mean value of 16±2 after the match. Our findings are consistent with values reported by Amtmann et al [22] who demonstrated that RPE' scores in a match of mixed martial arts (MMA) ranged from 13 to 19.

Moreover, HR showed a variation during the whole time of kickboxing match and attained a value of 180 ± 5 bpm for AR group. Many studies have reported a significant increase in HR during matches of different striking combat sports [23,24]. Finally, blood lactate increased significantly during the combat and reached 14.93±0.71 $mmol.l^{-1}$ for AR group and 14.87±0.69 $mmol.l^{-1}$ for PR group. These results demonstrated an activation of the anaerobic glycolysis during combat. Amtmann et al [22] have reported a mean value of blood lactate of 15.2±4 $mmol.l^{-1}$ after a MMA match. The values measured in our study were higher than those measured in other striking combat sports such as boxing [25], kung fu [20], Muay Thai [26] and taekwondo [24], suggesting that kickboxing seems to rely more on anaerobic glycolysis compared to these other striking combat sports.

For the recovery process effect, performances in vertical jump tests and in 30s Wingate test (i.e. PP) showed no significant difference between the two types of recovery. Our findings were in agreement with the study of Franchini et al [12]. In the same context, similar results were also found in several articles using different performance tasks [6,10,11].

The fact that AR did not result in improvement in performance in comparison to PR can be explained by the intensity used during recovery (i.e. 50% of maximal aerobic speed) which thereby confirms the findings of Dorado et al [27] who suggested that when the intensity of the active recovery is relatively high (i.e. 50% of maximal aerobic speed), active recovery would fail to show beneficial effects on subsequent performance.

However, in terms of recovery duration, some studies [6,11] suggested that when recovery duration is above 15min, no difference is observed in performance between AR and PR. For our study and despite the recovery duration used - which was less than 15min (i.e. 10min), we obtained no differences in performance in subsequent exercises after the recovery period. Additionally, other studies have shown that when the recovery is longer than 120s, performance in the subsequent exercise is improved after AR compared to the PR one [4,28].

Nevertheless, MP was significantly higher after PR when compared to AR. Unlike our results, Bogdanis et al [5] showed that AR resulted in a significantly higher MP compared with PR and several studies have reported a beneficial effect on performance when the muscles are warmer [28,29]. Mohr et al [29] found a positive correlation between the decrease in muscle temperature and sprint performance in a soccer match. This assertion is in disagreement with our findings because despite the longer time of recovery wherein muscle temperature can decrease until rest values [29], the PR was more beneficial in MP recovery compared to AR. The beneficial effect of PR in subsequent exercise can be assigned to a higher muscular reoxygenation [30].

Blood lactate measured during AR was lower than during PR. This difference was reached at the 5th and 10th minutes. Similar results were obtained after judo matches [12,13]. Franchini et al [13] had reported that AR resulted in higher blood lactate removal than PR in minutes 10 and 15, while Franchini et al [12] showed that AR resulted in faster lactate removal in the 9th, 12th and 15th minutes. However, the time when the difference started (5th minute) in our study was not similar to previous studies (9th and 10th minutes, respectively) [12,13]. This difference can be attributed to the intensity used during this procedure. Unlike our results, Touguinha et al [15] found no difference in blood lactate concentration after 9 min of AR or PR after a judo specific task. In fact, many explanations can be attributed to the mechanism of lactate disappearance such as the oxidation in skeletal muscles [31]. The enriched H lactate dehydrogenase (H-LDH) isozyme content in slow twitch fibers (LDH-1+LDH-2) [32] suggest that the delivery, uptake and subsequent oxidation of lactate are facilitated when these fibers are activated during low-intensity exercise, as well as the rate of blood flow which influences lactate efflux from skeletal muscle [33].

CONCLUSION

AR was more beneficial for lactate removal after the match, but this did not result in performance improvement, as PR resulted in higher MP after 10-min recovery compared to AR. Thus, 10min of recovery can be adopted in kickboxing competitions as a minimal interval time when successive matches take place.

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Conflict of interests: None

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