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Influence of massage, active and passive recovery on swimming performance and blood lactate

S. ALI RASOOLI [1], M. KOUSHKIE JAHROMI, A. ASADMANESH, M. SALESI

[1]International division, Shiraz University, Iran
[2]Department of Physical Education and Sport Science, School of Education and Psychology Shiraz University, Iran

***Aim*. Recovery is an important part of athletic training. The aim of this study was to evaluate influences of three methods of recovery including massage, active and passive recovery on blood lactate concentration and subsequent swimming performance of elite swimmers.**

***Methods*. Seventeen professional male swimmers (age:21± 2.4 years, height: 175.35±9.1 cm, weight: 67.66± 11.88 kg) voluntarily participated in this study. Two Swimming trials performed in every session which involved 200 m of front crawl swimming with maximal effort separated by ten minutes interval (recovery) period. Statistical method of repeated measures was used for analysis of data.**

***Results*. There was significant difference in blood lactate after three types of recovery (P<0.05). Significant difference was observed between passive and active (P=0.001), passive and massage (P=0.031) and active and massage (P=0.001). Blood lactate decreased after active, massage and passive recovery (blood lactate mean ± SD: 5.72±1.44, 7.10±1.27, 10.94±2.05 mmol/L, respectively). A significant difference was observed between performance time after three type of delivery (P=0.001, F=2.238). Significant differences was observed between passive and active recovery (P=0.003), passive and massage (P=0.001), but no significant difference was observed between performance time after active and massage recovery (P=1.00).**

***Conclusion*. the results indicated that active recovery was more effective than massage and massage was more effective compared to passive recovery in removing blood lactate. Active and massage recovery were more effective in improving swimming performance than passive recovery.**

Key words: Massage - Swimming - Athletic performance.

During competition season, swimmers often have to perform several final race formats or multiple races in a day. In these situations swimmers have to swim in maximal effort with short rest interval. In situation of short resting interval, different kinds of recovery type may be used. Active, passive and massage are three main methods of recovery which are commonly used and may influence blood lactate and swimming performance.

During Short bouts of sprint exercise, anaerobic glycolysis causes increasing muscle lactate. It is widely accepted that increasing blood lactate may retard recovery from fatigue and lactate elimination from blood and muscle can influence on recovery following maximal exercise.[1, 2] Some researchers have indicated that active recovery is more effective in reducing blood lactate than passive recovery [3-5] and massage.[6] It has been suggested that excessive lactate accumulation is associated with sport performance fall [7] and can be explained by increasing H+ as a result of lactic acid accumulation which act as force depressing factor.[8] However, in a study on Judo players, Lactate removal was increased by active recovery comparing passive recovery but active recovery did not result in improving performance.[9] One study indicated increased performance on a 200-yard (182.88 m) swimming after active compared to passive recovery,[10] while many studies indicated negative effect of active recovery on swimming performance.[11-14] Some researchers have advised passive recovery during repeated swimming sprints of

Corresponding author: M. Koushkie Jahromi, Department of Physical Education and Sport Sciences, School of Education and Psychology, Shiraz University, Shiraz, Iran. E-mail: koushkie53@yahoo.com

short duration,[3] while another study has indicated that applying active recovery between repeated boats facilitated swimming performance more than passive recovery.[15] massage is also one of recovery type which is recommended by many coaches.

Massage can improve stretching of tendons and connective tissue and cause relief of muscle tension [16] and by enhancing muscle blood flow, speed up muscle recovery.[17] Massage can increase blood flow and result in removal of lactate after exercise. Massage may increase oxidation and diffusion out of lactate from muscle.[18] However, Some studies have not supported influence of massage on lactate removal or sport performance, but have indicated psychological benefits of massage in boxing.[19] One study compared influence of sport massage, active and passive recovery in promoting blood lactate removal after submaximal exercise and indicated that after supramaximal leg exercise, active recovery produced significant decreases in blood lactate compared with massage and rest recovery. No significant difference was observed between passive and massage recovery on blood lactate removal.[6] Massage techniques and duration vary widely, thus limit the ability to compare one massage study to another.[20] Classical western massage or Swedish massage is the most common form of massage used for athletes and consists of five basic techniques known as effleurage, petrissage, tapotement, friction and vibration.[21]

So, Regarding importance of recovery on subsequent performance and lactate removal, yet there is not clear finding about which type of recovery (active, passive and massage recovery) is more effective on swimming performance. Therefore, the purpose of this study was evaluating and comparing effects of common types of recovery including passive, active, and massage during rest interval on blood lactate and 200 m swimming performance.

Materials and methods

Seventeen professional male swimmers (age: 21± 2.4 years, height: 175.35±9.1 cm, weight: 67.66± 11.88 kg) voluntarily participated in this study. All swimmers were members of national team at least for 5 years. Shiraz University ethical committee approved this study. All swimmers were informed of study aims and procedures and signed informed consent. During study period they had their usual training, but refrained from heavy training 24 hours before every testing sessions. The water and fluid consumption of subjects were controlled and assimilated during 8 hours before testing sessions.

This study used repeated measures under three experimental conditions including sport massage, active recovery and passive recovery. Swimmers performed three testing sessions over a period of three weeks. The order of conditions was determined using simple random assignment. Two Swimming trials in every session involved 200 m front crawl swimming with maximal effort separated by ten minutes interval period. All tests took place in the afternoon in a 50 m indoor swimming pool. water temperature was 24-25 °C. All swimmers performed trials after the same controlled warm up of 1000 m as described by Touberkis *et al.*[22]

The sport massage techniques were employed in this study included effleurage, petrissage, tapotement and compression which was performed by a masseur. The progression of the massage advanced from distal to proximal and lasted 10 min. It began and ends with light gliding strokes with the palm of the hand known as effleurage. The initial effleurage stroked then progress to deeper stroking known as petrissage. Petrissage involves a kneading motion or lifting, pressing or rolling of the tissues. Tapotement (percussion) involves stimulating the tissues either with repetitive percussion strokes or tapping.[25] The technique details and duration has been indicated in Table I.

Active recovery included swimming at a pace corresponding to 65% of the best 200 m individual velocity. Passive recovery involved sitting on the pool desk. Before and following recovery each participant swam 200 meter in maximal effort. Blood lactate was measured before and immediately after 1st swimming and after recovery (just before 2nd swimming). Blood sample (1-2 drops of blood) was taken from the ear and lactate concentration was measured with an Accutrend portable lactate analyzer (Manheim, Germany).

Statistical analysis

Normal distribution of the data was tested using Kolmogrov- Smironov test. A repeated measure test was used to compare two swimming performance and blood lactate in every condition (before and after

TABLE I.—*Sport massage protocol*

Muscle group	Technique				Time (min.s)
Back muscles	Jostling stroke (45 s)	Compressive stroke (40 s)	Petrissage and friction (1 min)	Jostling and compressive stroke (1 min)	3.30
Left upper and lower arm muscles	Jostling stroke (15 s)	Petrissage (20s)	Compressive stroke (15 s)	Effleurage (10 s)	60
Right upper and lower arm muscles	Jostling stroke (15 s)	Petrissage (20s)	Compressive stroke (10 s)	Effleurage (10 s)	60
Left posterior thigh and leg muscles	Jostling stroke (15 s)	Petrissage (20s)	Compressive stroke (10 s)	Effleurage (10 s)	60
Right posterior thigh and leg muscles	Jostling stroke (15 s)	Petrissage (20s)	Compressive stroke (10 s)	Effleurage (10 s)	60
Left quadriceps	Jostling stroke (15 s)	Petrissage (20s)	Compressive stroke (25 s)	-	60
Right quadriceps	Jostling stroke (10 s)	Petrissage (20s)	Compressive stroke (25 s)	-	60
Back and shoulder girth muscles	Tapotement				30
					Total time: 10 min

TABLE II.—*Blood lactate concentration (mmol.l-1) and performance time (second) in different measures (mean±SD).*

Parameter	Passive (N.=17)	Active (N.=17)	Massage (N.=17)
Lactate before 1st performance	1.74±0.10	1.75±0.10	1.72±0.10
Lactate after 1st performance	12.67±2.59	11.67±1.10	11.56±1.76
Lactate after recovery	10.94±2.05	5.72±1.44	7.10±1.27
1st performance time	146.93±13.68	144.42±12.93	146.00±13.53
2nd performance time	156.06±14.11	147.78±14.87	148.78±12.14

treatment). Analysis of variance with repeated measures were used to determine whether there were significant differences in blood lactate and performance time changes as a result of three methods of treatments including active, passive and massage recovery. A Bonferroni post hoc test was used to locate observed difference. The accepted level of significance was set at P<0.05.

Results

Results of repeated measure test revealed significant increase in blood lactate after first performance before passive (P=0.001), active (P=0.001), and massage (P=0.001) and significant decrease after ten minutes of active (P=0.001), and massage (P=0.001) but not significant decrease after passive recovery (P=0.071).

There was no significant difference between blood lactate after 1st performance (before performing three types of recovery) (P>0.05). There was significant difference in blood lactate after three types of recovery (P<0.05). Significant difference was observed between passive and active (P=0.001), passive and massage (P=0.031) and active and massage (P=0.001). According to figure 1 and table 1 blood lactate has decreased after active, massage and passive recovery (blood lactate mean ± SD: 5.72±1.44, 7.10±1.27, 10.94±2.05 mmol/L, respectively).

There was no significant difference in performance time before three types of recovery (P>0.05). A significant difference was observed between performance time after three type of recovery (P=0.001, F=2.238). Significant differences was observed between passive and active recovery (P=0.003), passive and massage (P=0.001), but no significant difference was observed between performance time after active and massage recovery (P=1.00). According to table 1 and figure 2 performance time after active, massage and passive recovery were 147.78 ±14.87, 148.78±12.14, and 156.06±14.11 seconds respectively.

In summary our findings indicated that after 200 m swimming, active recovery was the more effective than massage and massage was more effective com-

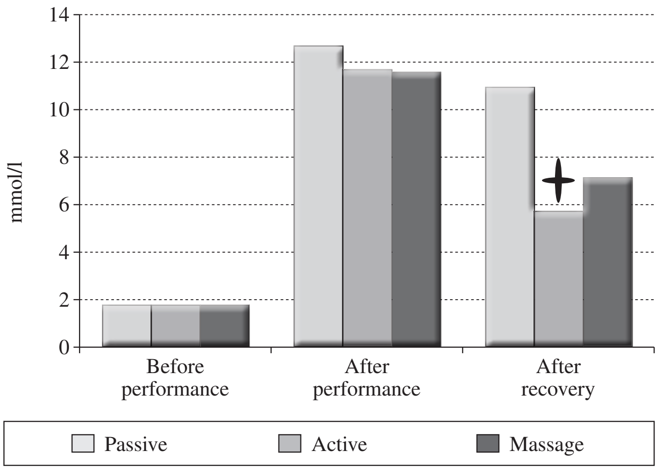

Figure 1.—Blood lactate concentration (mmol/L) for passive, active and massage recovery interval. Significant difference between interventions (P<0.05)

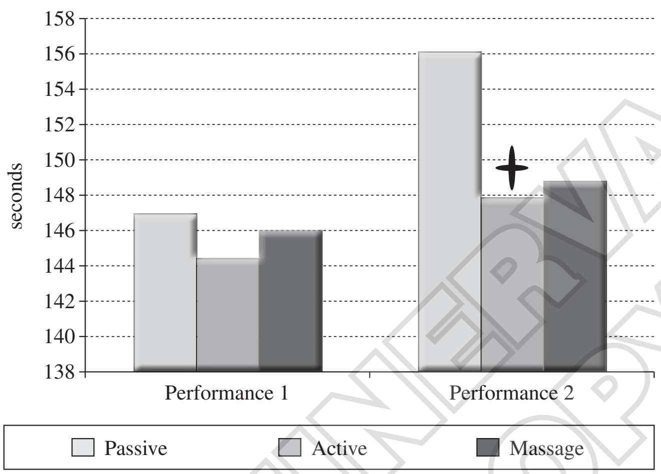

Figure 2.—Performance time (second) for passive, active and massage recovery interval. Significant difference between interventions (P<0.05).

pared to passive recovery in removing blood lactate and improving swimming performance (Figures 1, 2).

Discussion

The present study evaluated influence of three types of recovery including passive, active and massage on blood lactate concentration and 200 m swimming performance.

Findings of this study indicated significant increase of blood lactate concentration after 1st swimming performance. Blood lactate decreased following ten minutes of active recovery more than massage and passive recovery and massage was more effective than passive recovery in reducing blood lactate concentration.

Some studies found more blood lactate removal following massage rather than passive recovery.[23-26] The subjects and methods of present study was similar to Greenwood *et al.* (2008) [26] which supports our results. Findings of some research did not support our findings and indicated that there was no difference between blood lactate following massage and active recovery.[27, 28] Blood lactate concentration following exercise and recovery was influenced by a combination of lactate production, up take and oxidation.[2] Massage can increase blood flow and stimulate blood lactate removal.[21] Active recovery also can elevate blood flow in active muscles, which cause enhancing lactate diffusion out of muscles and its oxidation.[29] Blood flow was not measured in this study and the exact mechanisms of massage influence on blood lactate is unclear.[2] Nevertheless, according the findings of present study active recovery and massage can enhance lactate removal, but active recovery was more effective on reducing blood lactate compared to massage. During active recovery, although elevated metabolism is maintained but does not activate anaerobic glycolytic pathways to a great extent. Active recovery may increase use of lactate by heart and active muscles. Lactate which is produced in fiber II muscles can transport to fiber I or, IIa fibers to be oxidized. Thus exercise intensities lower than lactate accumulation increase lactate oxidization (2). Although some massage techniques increase blood flow,[21] but it is not associated with increasing metabolism. All of these mechanisms may explain better efficacy of active recovery than massage and passive recovery in lactate removal which was observed in present study.

It is possible that a kind of recovery which increases lactate removal is beneficial to short intense activities.[26] During short term maximal intensity exercise most of energy is provided through anaerobic glycolysis. The exact mechanisms by which glycogen breakdown is controlled during high intensity exercise is unclear.[30] During intensive exercise lactate dehydrogenize converts NADH+ H^+ + pyrovate to lactate. This reaction cause generating NAD^+ (which is consumed during first process of glycolysis reaction) which maintain glycolysis. Accumulation of Lactate depends on availability of oxygen relative to energy demands. Hydrogen ions increase in parallel with lactate ions, so during high intensity exercise there is decreasing of muscle PH from 7.0 to 6.5 and acidosis.[31] There is no biochemical support that lactate production causes acidosis but Lactate retards acidosis. During high intensity exercise, glycolysis and phosphagen systems cause acidosis. Lactate production increase to prevent pyrovate accumulation and supply NAD+ needed for glycolysis. So lactate accumulation coincides with cellular acidosis and is a good indirect measure of cell metabolic pathways which induce metabolic acidosis.[32]

Acidosis was considered the most important factor which impair contractile function of fatigued muscle, but recent evidences indicate that acidosis is not the most important cause of fatigue and acidosis observed in fatigued muscle (0.5 PH units) has little impact on force production, contractile speed and rate of fatigue development.[31, 32] Although it is probable that extracellular acidosis may activate III-IV afferent nerves and increase sensation of discomfort in fatigue.[33] Anaerobic glycolysis cause break down of phosphocreatine and cause increasing of P_i which can impair contractile function of skeletal muscle. It reduces the number of force generating by cross bridges and cause decreasing of force production and myofibril Ca2+ sensitivity.[35] P_i may enter the SR during fatigue which can increase Ca^{2+}-P_i solubility and decrease Ca2+ available for release [36] which can cause reducing muscle contractility.

The major finding of this study is that, although 2nd swimming performance time increased after ten minutes of interval recovery compared to 1st performance, active recovery and massage were more effective on improving swimming performance than passive recovery, but there was no significant difference between massage and active recovery on swimming performance.

Spierer *et al.* (2004) [37] findings supported our findings and indicated active recovery was more positively effective on swimming performance than passive recovery, but a study by toubekis *et al.* (2006) [22] indicated that active recovery at intensities of 50% and 60% of 100 m velocity during repeated swimming decreased performance. Jougla *et al.* (2010) [38] also indicated better performance of rugby players after passive recovery compared to active recovery (50% of maximal speed). Intensity of active recovery in different studies may be important determining factors of subsequent performance and lactate removal, because it influences workloads and energy cost.[39] Some researchers did not support influence of massage on performance of boxing [19] and cycling.[40] Boxing and cycling have different physiological demands and hence these findings may cause different results from our findings.

The duration of the rest interval separating trials is also very important factor for performance.[41] During short duration, high intensity exercise, muscle lactate and hydrogen ion concentration increase. Increasing hydrogen ion may cause decreasing subsequent performance.[2]Increasing concentration of hydrogen ion can decrease glycolytic activity and cause accumulation of inorganic phosphate which may impair muscular function.[33] Increasing 2nd performance time observed in this study may be explained by this mechanism.

Conclusions

According to our findings although subsequent swimming performances following active and massage were better than passive recovery but there was no difference between massage and active recovery in this regard. Some researches support psychological benefits of massage, although its physiological benefits on performance are in question.[19] It is probable that psychological benefits gained through massage in this study have resulted in greater effort in the second swimming performance In present study, blood lactate was removed following active recovery more than massage and it could enhance performance [42] but psychological benefits of massage may shed lactate influence.

According to findings massage or active recovery can be recommended to coaches and swimmers.

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