

EFFECT OF DIFFERENT RECOVERY MODALITIES ON ANAEROBIC POWER IN OFF-ROAD CYCLISTS

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ABSTRACT: Despite massage being widely used by athletes, opinions its effects on performance recovery differ. The aim of the study was reveal the effects of passive recovery (PR), sport massage (SM) and active recovery (AR) after series of Wingate anaerobic test (WAnT) on peak power (PP) and mean power (MP). Eleven junior off-road cyclists performed warm up on the cycle ergometer followed by 3 bouts of WAnT interspersed with 4 min rest. After 20 min of PR, SM or AR subjects performed fourth WAnT in random order one week apart. There was no significant difference in PP between PR and SM (875.5 ± 56.2 vs. 921.6 ± 50.8 W) but significant difference between PR and AR (875.5 ± 56.2 vs. 970.2 ± 68.9 W; $p < 0.05$). Significant differences were also found for MP between PR and AR (678.4 ± 45.2 vs. 746.1 ± 47.0 W; $p < 0.05$) but not for PR and SM (678.4 ± 45.2 vs. 714.6 ± 32.8 W). Blood lactate concentration after intervention was significantly different only between trials with PR and AR (13.3 ± 2.9 vs. 7.4 ± 3.9 mmol•L⁻¹; $p < 0.01$) and between SM and AR (14.6 ± 3.0 vs. 7.4 ± 3.9 mmol•L⁻¹; $p < 0.01$). A one-way ANOVA with repeated measure indicated that AR presents better modality in reducing blood lactate or renewal PP and MP than PR and SM.

KEY WORDS: Wingate anaerobic test, Sports massage, active recovery, passive recovery

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INTRODUCTION

Restoration of power output presents crucial factor not only during competition between repeated performances but also in training. There are many attempts to identify which recovery modality ensures better recovery and higher power restoration.

In several studies aiming at comparing active and passive recoveries, the performance exercise following active recovery was not improved despite lower lactate concentrations [4,29]. In other study, performance following the active recovery was improved, whilst the lactate concentrations, determined after the two recovery types (active versus passive), were not significantly different [3]. Similarly Bogdanis et al. [2] did not find relationship between muscle pH and power output restoration during second sprint. Many methodological variations including number of repeated sprints, rate of fatigue, recovery length, and intensity of active recovery contribute to different attitude to explanation of active recovery effects.

Based on literature we meet also equivocal beliefs on the efficacy the positive effect of sports massage by recovery from physical activity. Some athletes massage therapist and coaches support claims that massage can aid recovery and enhance performance. Although

a number of attempts have been made to investigate the effects of massage on repeated athletic performance, the outcomes have been contradictory, as indicated in previous literature reviews [12,21-23].

One reason for the controversy seems to stem from the different massage technique models used in the studies and which result in different magnitudes of damage to different muscles. Massage is widely used as a therapeutic modality for recovery from muscle fatigue and injury [7,23,26,27] and is probably one of the most popular treatments after sports activities. Although physiologic theory to support how massage facilitates recovery from eccentric-exercise-induced muscle damage is obscure [26]. Much of the supportive suggestion of the popular massage literature for the positive effects of massage application is recommended to verify with scientific data obtained using modern laboratory equipment and methods.

In order to avoid incorrect results from study in the field of sports massage that has been flawed by many methodological variations including: inconsistent massage duration, no standardization of warm up, absence of a period of active recovery when comparing massage

with other interventions, and often no standardization of physical activity performed preceding the massage.

We controlled the study with incorporating certain aspects: conditions before the intervention well controlled and standardized and greater experimental control (accurate length of massage and active recovery, intensity of exercise), to assess the potential benefits of massage and active recovery on subsequent high intensity exercise performance.

The purpose of the study was to reveal the effects of passive recovery, sport massage and active recovery after series of Wingate anaerobic test (WAnT) on peak power and mean power. The second purpose of the study was confirming no effectiveness of manual massage on lactate clearance as stated from previous studies [10,20,22,23]. We hypothesized that active recovery, allowing greater blood flow to fatigued muscles [2], would restore anaerobic power in greater amount.

MATERIALS AND METHODS

Subjects. Eleven junior elite Slovakian off-road cyclists participated for this study. The subjects were 19.29 ± 1.38 yr of age, 181 ± 4.26 cm in height, 66.75 ± 5.28 kg in weight and their maximal oxygen consumption was 66.66 ± 2.77 mL•kg⁻¹•min⁻¹. The experimental procedure was approved by the local scientific committee. Each subject and their parents were fully informed of the procedures to be used as well as the purpose of the study, and each subject or guardians of minors gave informed written consent. Subjects were asked to refrain from any form of intense physical exercise during the experimental period.

Experimental design. This was a prospective cross-over study comparing the effects of passive recovery, sports massage and active recovery on performance during a repeated Wingate anaerobic test (WAnT). Subjects entered the laboratory on five separate occasions one week apart and at the same time of day. Familiarization was completed on the first and second visit to ensure that they all knew the protocol and could complete the amount of work required. On first day the subjects completed a graded exercise test to determine maximal oxygen consumption (VO_{2peak}). On the second day the subject executed three (WAnT) interspersed with 4 min of passive rest between each WAnT to ensure appropriate practice. After this familiarization period, the subjects entered the experimental phase one week later. Subjects performed a standardized light warm up (consisting of five min of cycling at load of 1.5 W on kg body weight and a short stretching period) and special warm up by Inbar [14] which included three 8 seconds sprints at the end of the first, third and fifth min. We used toe clips to maximize the involvement of both the quadriceps and hamstrings muscle groups. The experimental protocol consisted of three bouts of WAnT interspersed with 4 min of passive rest followed by 20 min of passive recovery, sport massage or active recovery assigned in a randomized cross over fashion one week apart. After the intervention period, the subject then completed fourth WAnT.

Recovery modalities. During passive recovery the subjects rested in supine position with the straight legs and arms positioned alongside the body. Sports massage was applied for ten minutes to the neck and upper parts of the back in a prone position followed by eight minutes to the front and back of the legs with the subject in a prone position. Massage was applied to the front and back of the right then the left leg (each for four minutes). The legs were in straight position when massaging the front and in a bent position at the knees when massaging the back of the legs.

The massage techniques for first part of treatment were employed to elicit a relaxed condition. The last two minutes were administered as a warm up massage of right and left leg, where the employed massage techniques were fast irregular effleurage and tapotement. All massage was administered by the same certificated massage therapist using a conventional massage lotion (Emspoma, Czech Republic) to reduce friction between therapist's hands and subject's skin. Active recovery consisted of ten minutes cycling on ergometer at the power intensity corresponding to 20% of VO_{2peak} and then the next ten minutes at 40% VO_{2peak}. 20% of VO_{2peak} during initial minutes was established because athletes, due to profound fatigue, were unable to sustain higher power intensity, as found out in pre-experimental phase.

Dependent variables. Each series of modified WAnT were completed in isokinetic regimen using cycle ergometer Ergocycle (Slovakia) which enable maintain constant cadency according selected frequency revolution per minute [15,16]. The pedal cadency was set at a frequency of 100 revolutions per minute. WAnT variables were recorded through a PC interface (Ergocycle, Slovakia) and included peak power (W), mean power (W), and fatigue index (percentage change in power output between the first five seconds and the last five seconds of the 30 second exercise period). 20 μl capillary blood samples from finger tip were drawn for lactate analysis at rest immediately before first WAnT and in the third minute after completing first, second and third WAnT, immediately before fourth WAnT and in the third minute after. Blood lactate growth (concentration of blood lactate before minus concentration of lactate after fourth WAnT) was used as an indirect method of anaerobic glycolysis rate. Blood lactate samples were measured using a Biosen C line (Germany). Heart rate (mean of minute interval) was recorded throughout the protocol using Polar monitor S 610i (Finland).

Statistical analysis. Changes in performance of repeated WAnT during session were evaluated by two – way analyses of variance (ANOVA) with repeated measures. A one–way ANOVA with repeated measure was performed to investigate differences in blood lactate levels, power variables (peak power, mean power, fatigue index) and heart rate between conditions. Data analysis was performed using a statistical software package (SPSS version 13.0; SPSS Inc, Chicago, IL). Where appropriate, a Tukey's post-hoc test was used to identify significant differences. A significance level of $p < 0.05$ was established prior to analyses. Data are presented as mean \pm SD.

RESULTS

As shown in Fig. 1, after subjects underwent single recovery interventions statistic analyses did not confirm a significant difference in peak power between passive recovery and sports massage (875.5±56.2 vs. 921.6±50.8 W). However there was a significant difference between passive recovery and active recovery (875.5±56.2 vs. 970. ± 68.9 W; $p<0.05$) (Fig. 1).

Significant differences were also found for mean power (W) between passive recovery and active recovery (678.4±45.2 vs. 746.1±47.0 W; $p<0.05$) but not for passive recovery and sports massage (678.4±45.2 vs. 714.6±32.8 W) (Fig. 2). No significant effect was observed on the fatigue index between passive recovery, sports massage and active recovery (33.6±8.4%, 329±6.5%, 35.2±7.7%).

As shown in Fig. 3 after recovery blood lactate concentration (mmol•L⁻¹) was significantly different only between trials with passive recovery and active recovery (13.31±2.9 vs. 7.49±3.9 mmol•L⁻¹, $p<0.01$) and between sports massage and active recovery (14.68±3.0 vs. 7.49±3.9 mmol•L⁻¹, $p<0.01$). Blood lactate concentration after fourth WAnT, which followed 20 min recovery, was not significant in trial with sports massage, passive rest or active recovery. The growth of lactate in the blood after fourth WAnT was

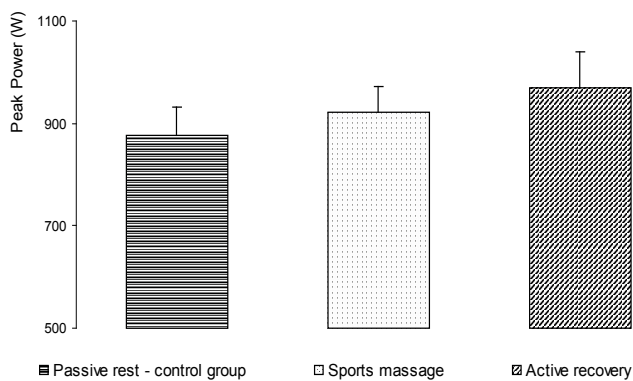


FIG. 1. PEAK POWER IN FOURTH WINGATE ANAEROBIC TEST. PASSIVE REST REPRESENTS THE CONTROL GROUP. VALUES ARE SHOWN AS MEAN ± SD. SIGNIFICANTLY DIFFERENT FROM BASELINE: * $p<0, 05$.

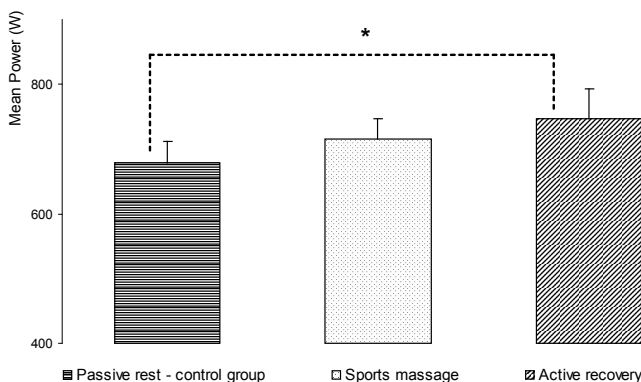


FIG. 2. MEAN POWER IN FOURTH WINGATE ANAEROBIC TEST. PASSIVE REST REPRESENTS THE CONTROL GROUP. VALUES ARE SHOWN AS MEAN ± SD. SIGNIFICANTLY DIFFERENT FROM BASELINE: * $p<0, 05$.

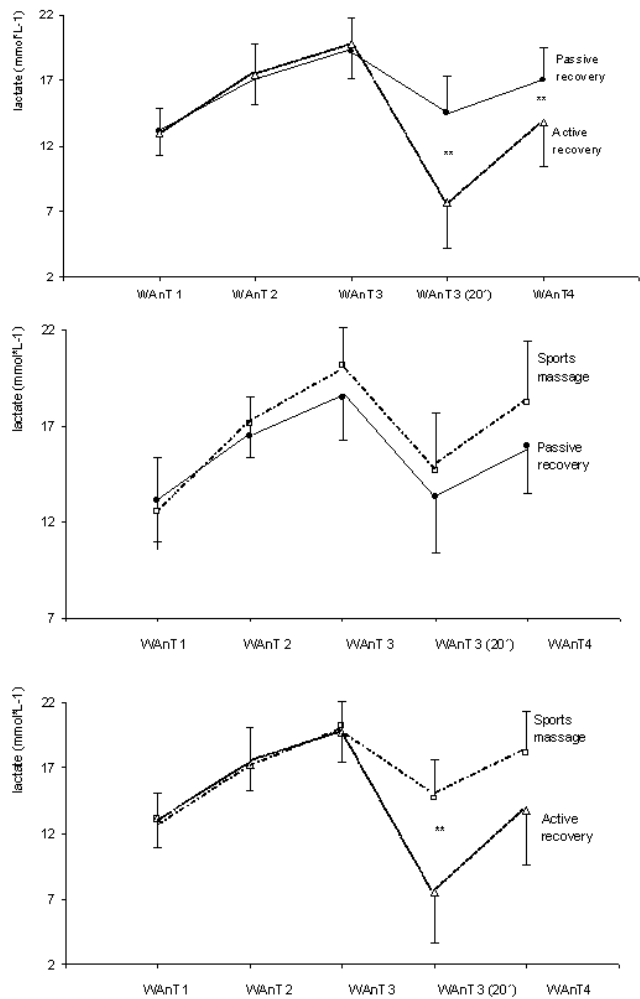


FIG. 3. MEAN BLOOD LACTATE CONCENTRATION AT 3. MIN AFTER THE WINGATE TESTS (WAnT 1- WAnT 3), AFTER 20 MIN INTERVENTION (WAnT 3 (20')) AND AT 3. MIN AFTER THE WAnT 4. PASSIVE REST REPRESENTS THE CONTROL GROUP. VALUES ARE SHOWN AS MEAN ± SD. SIGNIFICANTLY DIFFERENT FROM BASELINE: ** $p<0, 01$.

higher for active recovery than sports massage (6.27±1.01 vs. 3.47±0.62 mmol•L⁻¹, $p<0.01$) and passive recovery (2.63±0.92 mmol•L⁻¹, $p<0.01$). There were not find significant difference in the net accumulation of lactate in blood between passive recovery and sports massage.

No significant difference in responsive heart rate was noted at any time before, during, or after the intervention with sports massage and passive rest. Average heart rate (bpm) during active recovery (125.0±12.4, $p<0.01$) was significantly higher than during passive rest (105.1±8.2) and sports massage (103.9±7.5). There was no significant difference between sports massage and passive rest.

DISCUSSION

Despite no measurable effect of sports massage was observed on lactate clearance and heart rate after repeated bouts of high intensity effort, this study indicates a slight but not significant difference in muscular performance in the massage when comparing with passive intervention trial. This finding supports previous research showing that manual massage does not affect the recovery

from high intensity exercise [12,23]. Some current claims made in massage literature present the benefits of massage by increasing blood flow to the muscles being massaged [19]. Research findings do not support a positive effect of manual massage in elevation of arterial and venous mean blood velocity above resting levels [22,23]. However Lowe and Chaitow [19] appeal against with the argument that in these studies the measurement of blood flow change was by mean blood velocity through large arteries. They advocate that the effect of massage induced increase in microcirculation is often immediately apparent with the superficial hyperemia and warmth of the skin in the area that has been treated with massage. Mori et al. [22] ascertained increased intramuscular blood volume during massage of the lower back. Likewise Travell [28] suggests that one of the most significant effects of massage is the encouragement of blood flow into capillaries that are restricted due to muscle tightness. On the other hand research findings of Hinds et al. [14] claim that post-exercise massage increases blood flow to skin but not to the femoral artery, potentially diverting blood flow away from recovering muscles. It is difficult to explain how massage accelerate a post exercise recovery because no authors have yet described the effects of massage on cellular events or pathophysiologic changes in the muscle or connective tissue after exercise. Furthermore, evidence suggests that body massage is believed to be ineffective in enhancing the lactate removal and that an active type of recovery is the best modality for enhancing lactate removal after exercise [10,20].

The results of this study suggest that active recovery not only enhance lactate removal but contribute to higher power restoration. Bogdanis et al. [2] advocate beneficial effects of an active recovery by an increased blood flow to the previously exercised muscle. It is likely that increased blood flow during active recovery has the main effect on recovery from high intensity intermittent exercise. Nevertheless evidence suggests that increases in blood flow alone have little or no effect on lactate clearance [27]. Active recovery serves to maintain an elevated metabolic rate but does not activate anaerobic glycolytic pathways to a great extent. The elevated metabolic rate during active recovery serves to promote lactate clearance via an accelerated rate of lactate oxidation [5,9]. The changes in lactate concentration after exercises are parallel to the changes in pH values [4,24]. Despite the findings of Bogdanis et al. [2] about nonsignificant correlation between intramuscular pH and peak power restoration there is certain support from literature that decline in maximal voluntary contraction correlate with muscular pH decrease and that recovery of power output during repeated sprint exercise is

enhanced when low-intensity exercise is performed between sprints [3,8,13,25].

Monedero and Donne [21] found that combined recovery (massage and active recovery) was the most efficient intervention for maintaining maximal performance time during repeated 5 km maximal effort cycling than passive and either active or massage. On the contrary, in the study of Lau et al. [18] 15 min active recovery (low-intensity cycling) did not enhance lactate removal or subsequent performance of repeated work bouts in simulated hockey play. Passive vs. active recovery showed no statistically significant differences for the distance skated, heart rate, or lactate.

Some authors explain the psychological effects of massage on athlete's trust in the treatment [15,19]. On the contrary some authors admit there is evidence of psychological regeneration following massage by monitoring for perceived recovery [6,12]. The sensation of wellbeing following massage may be explained in plasma endorphin concentration increase [17].

CONCLUSIONS

The studies using long distance runners [28], game players [8] and boxers [5] suggest that massage may have minimal influence on the physiological indices of muscle recovery.

This study did not find any physiological effect of sports massage. It was confirmed that sports massage has no superior effect to passive recovery in terms of power output restoration. However active recovery appears as the best modality not only in terms of blood lactate clearance but also in term of power output restoration. Nevertheless in disciplines like decathlon or modern pentathlon it could be speculated that combined recovery (massage and active physical activity) may help keep higher vitality during the event. It is clear that much more research needs to be done before the effect of manual massage on restoration after exercise can be fully defined. Current evidence supports active recovery as a useful treatment in enhancing short-term recovery. This study was aimed to assess efficiency of recovery from repeated high intensity anaerobic power. The results from this study may not have been confronted with studies using different massage methods or different exercise protocols.

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REFERENCES

1. Baron R., Bachl N., Petschnig R., Tschan H., Smekal G., Pokan R. Measurement of maximal power output in isokinetic and non-isokinetic cycling. *Int. J. Sports Med.* 1999;20:532-537.
2. Bogdanis G., Nevil M., Boobis L., Lakomy H., Nevill A. Recovery of power output and muscle metabolites following 30 s of maximal sprint cycling in man. *J. Physiol.* 1995;482:467-480.
3. Bogdanis G., Nevil M., Lakomy H., Graham C., Louis G. Effects of active recovery on power output during repeated maximal sprint cycling. *Eur. J. Appl. Physiol.* 1996;74:461-469.
4. Bond V., Adams R.G., Tearney R.J., Gresham K., Ruff W. Effects of active and passive recovery on lactate removal and subsequent isokinetic muscle function. *J. Sports Med. Phys. Fitness* 1991;31:357-361.

5. Brooks G.A. Current concepts in lactate exchange. *Med. Sci. Sports Exerc.* 1991;23:895-906.
6. Dawson L., Kimberley A., Tiidus P.M. Evaluating the influence of massage on leg strength, swelling and pain following a halfmarathon. *J. Sports Sci. Med.* 2004;3:37-43.
7. Ernst E. Does post-exercise massage treatment reduce delayed-onset muscle soreness? A systematic review. *Br. J. Sports Med.* 1998;32:212-214.
8. Fitts R. Mechanisms of muscular fatigue. In: J.R. Portmans (ed.) *Principles of Exercise Biochemistry*. 3rd Ed. Karger, Basel 2003;pp. 279-300.
9. Gladden L.B. Lactate metabolism during exercise. In: J.R. Portmans (ed.) *Principles of Exercise Biochemistry*. 3rd Ed. Karger, Basel 2003;pp.152-196.
10. Gupta S., Goswami A., Sadhukhan A.K., Mathur D.N. Comparative study of lactate removal in short term massage of extremities, active recovery and a passive recovery period after supramaximal exercise sessions. *Int. J. Sports Med.* 1996;17:106-110.
11. Hamar D., Gazovic O., Schickhofer P. Isokinetic cycle ergometer- application in sports medicine. *Wien med. Wochenschr.* 1995;145:606-610.
12. Hemmings B., Smith M., Graydon J., Dyson R. Effects of massage on physiological restoration, perceived recovery, and repeated sports performance. *Br. J. Sports Med.* 2000;34:109-115.
13. Hermansen L., Stensvold I. Production and removal of lactate during exercise in man. *Acta Physiol. Scand.* 1972;86:191-201.
14. Hinds T., Mcewan I., Perkes J., Dawson E., Ball D., George K. Effects of massage on limb and skin blood flow after quadriceps exercise. *Sports Exerc.* 2004;36:1308-1313.
15. Illingworth P. Trust: the scarcest of medical resources. *J. Med. Philos.* 2002;27:31-46.
16. Inbar O., Bar-Or O., Skinner J.S. *The Wingate Anaerobic Test*. Human Kinetics, Champaign, IL. 1996.
17. Kaada B., Torsteinbo O. Vasoactive intestinal polypeptides in connective tissue massage. *Gen. Pharmacol.* 1987;18:379-384.
18. Lau S., Berg K., Latin R.W., Noble J. Comparison of active and passive recovery of blood lactate and subsequent performance of repeated work bouts in ice hockey players. *J. Strength Cond. Res.* 2001;15:367-371.
19. Lowe W., Chaitow L. *Orthopedic Massage*. Library of Congress. London 2003.
20. Martin N.A., Zoeller R.F., Robertson R.J., Lephart S.M. The Comparative effects of sports massage, active recovery, and rest in promoting blood lactate clearance after supramaximal leg exercise. *J. Athlete Training* 1998;33:30-35.
21. Monedero J., Donne B. Effect of recovery interventions on lactate removal and subsequent performance. *Int. J. Sports Med.* 2000;21:593-597.
22. Mori H., Ohsawa H., Tanaka T.H., Taniwaki E., Leisman G., Nishijo K. Effect of massage on blood flow and muscle fatigue following isometric lumbar exercise. *Med. Sci. Monit.* 2004;10:173-178.
23. Robertson A., Watt J.M., Galloway S.D. Effects of leg massage on recovery from high intensity cycling exercise. *Br. J. Sports Med.* 2004;38:173-176.
24. Sahlin K., Alverstrand A., Brandt R., Hultman E. Intracellular pH and bicarbonate concentration in human muscle during recovery from exercise. *J. Appl. Physiol.* 1978;45:474.
25. Sahlin K., Ren J. Relationship of contraction capacity changes during recovery from a fatiguing contraction. *J. Appl. Physiol.* 1989;67:648-654.
26. Tiidus P.M. Manual massage and recovery of muscle function following exercise: a literature review. *J. Orthop. Sports Phys. Ther.* 1997;25:107-112.
27. Tiidus P.M. Massage and ultrasound as therapeutic modalities in exercise-induced muscle damage. *Can. J. Appl. Physiol.* 1999;24:267-278.
28. Travell J.S. *Myofascial pain and dysfunction: the trigger point manual*. Williams and Wilkins, Baltimore, 1983.
29. Weltman A., Stamford B.A., Fulco C. Recovery from maximal effort exercise: lactate disappearance and subsequent performance. *J. Appl. Physiol.* 1979;47:677-682.