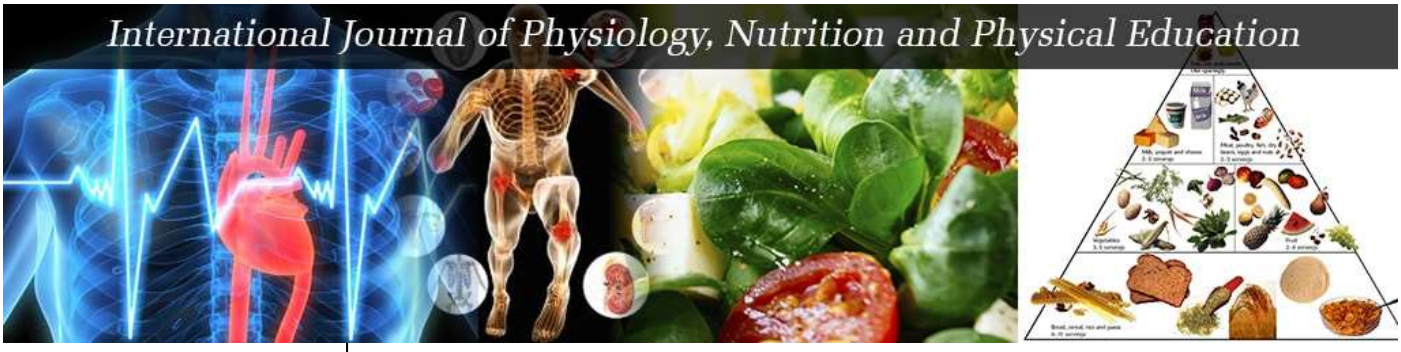

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An impact of different recovery training programs on VO2 max of basketball players: A comparative study

Ajit Singh, Shiv Kumar and Swati Choudhary

Abstract
Present study was undertaken to investigate the effect of recovery training programs on VO2 max of basketball players. A sample of Twenty (20) state-level basketball players with age group of 18 to 23 years belong to Birbhum, West Bengal, India were purposively selected as subjects for the study. Further all the subjects were randomly divided into four groups and each group had 05 subjects. Three experiential groups and one control groups were formed i.e., Experimental Group-I (Cold Water Immersion group, CWIG), Experimental Group-II (Massage group, MG), Experimental Group III (Low-Intensity Stretching Group, LISG) and Control Group (CG).
Before beginning the training program all the subjects were informed about the purpose and procedure of the study. Data on VO2max was measured with the help of Queen's College step test & the score was recorded in milliliters per kilogram per minute (Ml/kg/min) and [VO2 max = 111.33- (0.42 X step test pulse rate, beats/minutes)] equation was used to determine (VO2max) Maximum oxygen consumption before the beginning of basketball match, immediately after the basketball match and after the implementation of recovery training programs on experimental and control groups. Before collecting data and starting recovery program, the purpose of study was explained to all the subjects and participated voluntarily. The experiment was conducted during inter-club basketball tournament at sports authority of India special game centre, Birbhum, West Bengal. Initial pre-data was collected before starting the match then subjects played a full-length basketball match for 40 min thereafter again data was collected, and final data was collected after 15min. of recovery training programs under the proper supervision and guidance of the researchers whereas control group did not participate in any recovery program.
To investigate the effect of three types of recovery programs (Cold Water Immersion Program, Massage Program and Low-Intensity Stretching Program) on VO2 max of state-level basketball players, descriptive statistics, 4 X 3 Mixed (Between-Within) repeated ANOVA was used as the statistical technique and the level of significance was set at 0.05. In case of significant differences, pairwise comparisons were performed after Bonferroni adjustment.
Results of study showed that significant change was found in VO2 max of basketball players after administration of different recovery programs (Massage, Cold Water Immersion & Low Intensity Stretching Recovery Programs). It was very clear from the marginal means of VO2 max, among recovery durations irrespective of groups for the fast and better recovery of basketball players, cold water immersion recovery training program was superior in comparison to other recovery training programs (Massage and Low-Intensity Stretching). The linear significance was found in VO2 max among basketball players after administration of different recovery programs (Massage, Cold Water Immersion & Low-Intensity Stretching Recovery Programs). It may be attributed that the 15 minutes time was appropriate to produce a significant change in VO2 max as result of different recovery training programs.

Keywords: VO2 max, basketball players, recovery training programme

Introduction
Basketball is one of the fastest games in which repeated accelerations, sprints, jumps, change of directions and technical movements to be performed in each window of time, to carry out the strategy made by the players. At elite level, regular player actions, such as tackles, feints, and shots, are needed to be performed with overwhelming intensity to overcome opposition and be successful. Basketball players are often exposed to demanding training and competition schedules, which may include repeated, high-intensity exercise sessions performed on consecutive days, multiple times per week. Each training and game take toll the physical ability of player as they experience repeated moderate and rapid accelerations and

decelerations, explosive jumps, and muscle damage from eccentric loading or contact trauma. Excessive volumes of intense training and competition, with reduced recovery time results in great physiological demands on the musculoskeletal, nervous, immune, and metabolic systems, potentially causing a negative effect on subsequent exercise performance, and making players prone to overload injuries, especially during a congested fixture period where players have compete and train repeatedly over a short time frame, the capacity of a player to recover from intense training and competition is one of the more important determining factors as it may affect subsequent performance of player (Odetoyinbo *et al*., 2009) [1].

Over the past 30 years maximal aerobic capacity (VO2 max) has emerged as a strong predictor of adverse health outcomes such as cardiovascular disease and all-cause mortality (Keteyian *et al*., 2008; Myers *et al*., 2002) [5, 8]. Exercise training is an effective means of achieving improvements in VO2 max, with a rise of one metabolic equivalent (3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$) in VO2 max associated with a 10–25% improvement in survival (Kaminsky LA *et al.* 2013) [4]. Thus, exercise training represents a potentially important preventative approach to reduce the risk of disease development in currently healthy adults. Like any form of preventative medicine, there is a need for exercise prescription to be optimized with the goal of prescribing the most effective exercise intensity for improving VO2 max. Recovery should be made after each exercise that aims to eliminate lactic acid in muscles. Recovery immediately after training is a crucial factor for improving athlete performance. Recovery can reduce muscle soreness; this is due to eliminating lactic acid through increased microcirculation in muscles (Wiltshire *et al*., 2009; Pinar *et al*., 2012) [14, 9].

Active recovery includes preserving the sub maximum work after tiring training or competition with the purpose to keep the level of performance level in various events during training or competition. It could increase the recovery mechanism in energy, muscle, and psychological aspect of the athlete. The active recovery could be conducted in a different time, whether as the part of training session or during cooling down phase. In this case, it is usually started by another recovery method such as stretching and massage (Hausswirth & Mujika, 2013) [2]. In sport, massage is usually given before competition. Massage is good for health for its ability to expediting blood circulation in human body (Monedero dan Donne. 2000; Weerapong *et al*., 2005) [13]. The improvement of blood circulation is believed to improve the performance by improving the oxygen and nutrition to cell, improving intramuscular temperature and blood buffering effect. The improvement of blood circulation will improve the oxygen level in blood. It would push the process of reducing the lactic acid faster. The good recovery technique is a technique that could combine the recovery actively and passively (Monedero, 2000). Recovery is the most important part in improving an athlete performance. The fast recovery technique will fasten the performance of an athlete. The fast recovery technique will fasten the process of an athlete endurance thus the athlete could follow the training optimally to achieve the accomplishment. Massage is also used for preparing the athlete before and after the competition with different techniques including Swedish massage, that could reduce the pain and give a relaxation effect and also rehabilitation for the athlete to get a fast recovery (Purnomo, 2015) [10]. Similar research showed a result that active recovery and combination recovery could decrease the fatigue level on football athletes (Kurniawan & Elfarabi, 2018) [6]. However, the present research used a different subject, the basketball athletes.

Methodology

A sample of Twenty (20) state-level basketball players with age group of 18 to 23 years belonging to Birbhum, West Bengal, India were purposively selected as subjects for the study. Further all the subjects were randomly divided into four groups and each group had 05 subjects. Three experiential groups and one control group were formed i.e., Experimental Group-I (Cold Water Immersion group, CWIG), Experimental Group-II (Massage group, MG), Experimental group III (Low-Intensity Stretching Group, LISG) and Control group (CG).

Before beginning the training program all the subjects were informed about the purpose and procedure of the study. Data on VO2max was measured with the help of Queen's college step test & the score was recorded in millilitre per kilogram per minute (Ml/kg/min) and [VO2 max = 111.33- (0.42 X step test pulse rate, beats/minutes)] equation was used to determine (VO2 max) Maximum oxygen consumption before the beginning of basketball match, immediately after the basketball match and after the implementation of recovery training programs on experimental and control groups. Before collecting data and starting recovery program, the purpose of study was explained to all the subjects and participated voluntarily. The experiment was conducted during inter-club basketball tournament at sport authority of India special game centre, Birbhum, West Bengal. Initial pre data was collected before starting the match then subjects were played a full-length basketball match for 40 min thereafter again data was collected, and final data was collected after 15min. of recovery training programs under the proper supervision and guidance of the researchers whereas control group did not participate in any recovery program.

Statistical Technique

To investigate the effect of three types of recovery training programs (Cold Water Immersion, Massage and Low-Intensity Stretching) on VO2 max of state-level basketball players, descriptive statistics, 4 X 3 Mixed (Between-Within) repeated ANOVA was used as the statistical technique and the level of significance was set at 0.05. In case of significant difference, pairwise comparisons were performed after Bonferroni adjustment. Box's M test was found insignificant ($p > 0.001$); hence the assumption of homogeneity of variance-covariance matrices is not violated.

Results

Table 1: Descriptive Statistics of Pre-Match, Post Match and after Recovery Mean Data for VO2 max

	Groups	Mean	Std. Deviation	N
Pre-match	Cold Water Immersion Group	50.51	4.01	5
	Massage Group	50.51	4.01	5
	Low Intensity Stretching Group Control Group	49.17	2.65	5
		46.73	5.10	5
	Total	49.23	4.03	20
Post-match	Cold Water Immersion Group	32.70	6.96	5
	Massage Group	33.37	3.48	5
	Low Intensity Stretching Group	33.04	4.98	5
	Control Group	34.84	7.48	5
	Total	33.49	5.52	20
After-recovery	Cold Water Immersion Group	53.92	5.65	5
	Massage Group	58.56	8.92	5
	Low Intensity Stretching Group	52.57	8.68	5
	Control Group	44.72	8.28	5
	Total	52.44	8.94	20

Table 1 shows the scores of mean and SD of VO2 max of different groups with various time durations of basketball matches. It is found that mean scores of VO2 max of the Cold Water Immersion group were found highest among all the time durations. The pre-match means scores and SD of VO2 max for the cold-water immersion group, massage group, low-intensity stretching group and control group were 50.51±4.01; 50.51±4.01; 49.17±2.65; 46.73±5.10 respectively.

After match training duration, the mean scores and SD of VO2 max for the cold-water immersion group, massage group, low-intensity stretching group and control group were 32.70±6.96; 33.37±3.48; 33.04±4.98; 34.84±7.48 respectively.

The mean scores and SD of VO2 max after recovery of cold-water immersion group, massage group, low-intensity stretching group and control group were 53.92±5.56; 58.56±8.92; 52.57±8.68; 44.72±8.28 respectively.

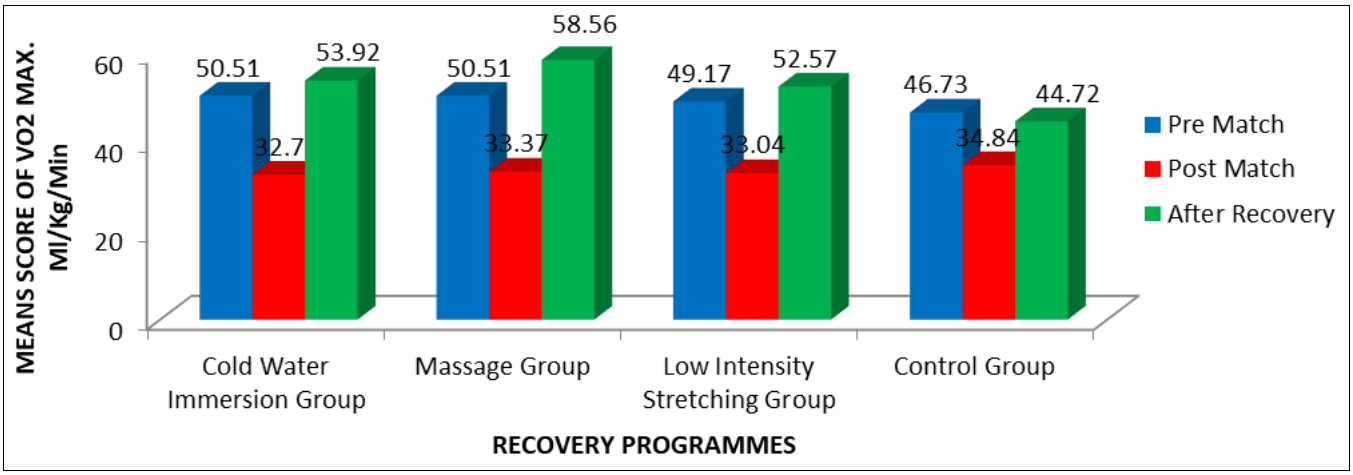

Fig 1: Graphical representation of Vo2 max between pre, post and after-recovery test means among the four groups

Table 2: Levene's Test of Equality of Error Variances of the data for Vo2 max

	F	df1	df2	p-value
Pre -match	0.85	3	16	0.48
Post-match	0.90	3	16	0.45
After recovery	1.04	3	16	0.40

Table- 2 This assumption is required to be tested because the mixed design consists of between-subjects factors also. This is an assumption of the independent measures of ANOVA. Since Levene's statistic for pre-match and post-match and after-recovery level of the within-subject factors (Duration) is non-significant (p> 0.05) as shown in table 4; hence the homogeneity of variance assumption is not violated.

Table 3: F-Table for Training Durations (Within-Subject Effect) and Interaction Effect of Recovery of vo2 max

Source		Type III Sum of Squares	Df	Mean Square	F	P- value	Partial Eta Squared
Duration	Sphericity Assumed	4115.56	2	2057.78	61.85	0.00*	0.79
Duration * Groups	Sphericity Assumed	330.82	6	55.13	1.65	0.16	0.23
Error (Duration)	Sphericity Assumed	1064.60	32	33.26			

*p-value < 0.05 is significant.

In the mix design, there are two independent factors, time and groups, whose effects need to be investigated. Here the time is a within-subjects factor and training groups is a between-subjects factor. Table 3 shows that there was a significant main effect of time on vo2 max as the calculated F-value (61.85) was found to be greater than tabulated f-value (F=3.30) with 2, 32 df at 0.05 level of significance (p-value < 0.05). It also shows that there was no significant interaction effect between groups and training durations as the calculated F-value (1.65) was found to be less than tabulated f value

(F=2.40) with 6, 32 df at 0.05 level of significance (p-value > 0.05). Partial eta square in above table 5 explains 79% of variance of time and 23% of variance was explained by the interaction effect, which shows variance of interaction between time and groups. Partial eta square of time indicates large effect size and interaction effects indicate small effect size.

Table 4: F- Table for Groups (Between-Subjects Effects) of vo2 max

Source	Type III Sum of Squares	df	Mean Square	F	p-value	Partial Eta Squared
Groups	226.13	3	75.37	1.53	0.24	0.22
Error	785.61	16	49.10			

*$F_{0.05}$> 3.24 (3, 16 df) is significant.

Table 4 shows that there was no significant main effect of groups (cold water immersion, massage, low-intensity stretching and control group) on vo2 max due to basketball match as the calculated F-value (1.53) was found to be less than the tabulated f value (F=3.24) with df 3, 16 at 0.05 level of significance (p-value > 0.05).

Partial eta squared in the above table explains 22% of the variance of groups, which indicates a small effect: size.

Table 5: Marginal Means of $VO_{2\ max}$ among Recovery Durations Irrespective of Groups (ml/kg/min.)

Duration	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Pre- match	49.23	0.90	47.31	51.14
Post-match	33.49	1.33	30.67	36.13
After recovery	52.44	1.78	48.65	56.23

From Table 5 it is clearly seen that the marginal mean of vo2 max for overall pre-match irrespective of groups (cold water immersion, massage, and low-intensity stretching and control group) suggests that its mean score and standard error of mean score were 49.23 and 0.90 respectively. The marginal mean of vo2 max for overall post-match irrespective of groups (cold water immersion, massage, low-intensity stretching and control) suggests that its mean score and standard error of mean score were 33.49 and 1.33 respectively. The marginal mean of vo2 max for overall after recovery irrespective of groups (cold water immersion, massage, low-intensity stretching and control) suggests that its mean score and standard error of mean score were 52.44 and 1.78 respectively. The marginal means of all the training durations are presented graphically below:

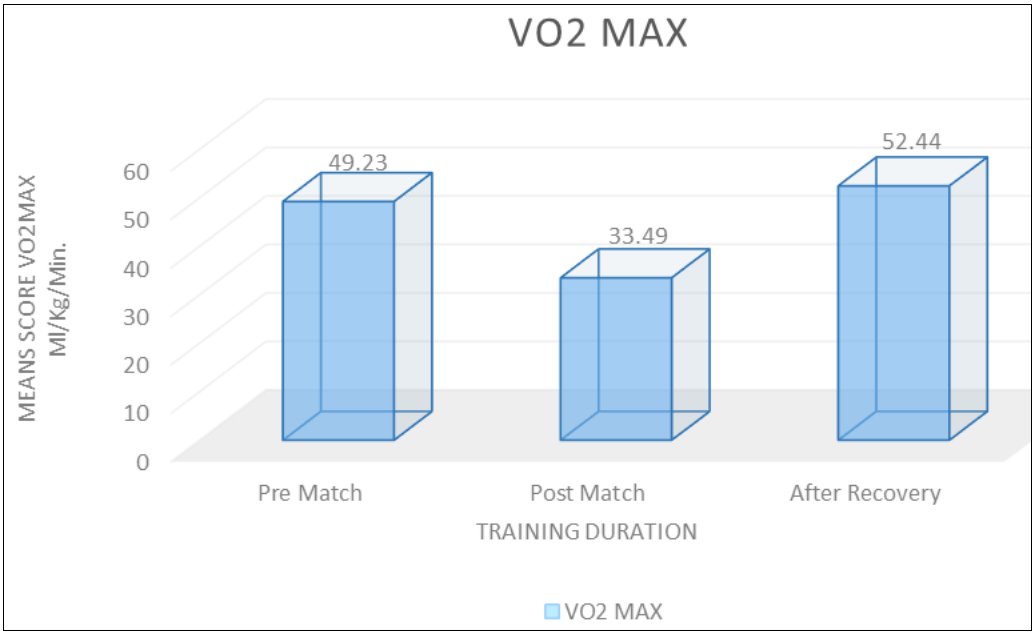

Fig 2: Marginal Means of VO2 max among Various Recovery Durations

From table 5 it is evident that there was a significant main effect of training duration. To compare different times (i.e., pre match, post-match and after recovery), pairwise comparisons were performed after Bonferroni adjustment, and the results are shown in the table underneath:

Table 6: Pairwise Comparisons between Recovery Durations of Recovery programme of VO_2Max (ml/kg/min.)

(I) Duration	(J) Duration	Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Pre-match	Post-match	15.74*	1.32	0.00	12.21	19.27
	After recovery	-3.21	1.88	0.32	-8.25	1.83
Post-match	After recovery	-18.94*	2.16	0.00	-24.73	-13.17

*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Table 6 shows that there was a no significant difference were found between pre match and after recovery as the p-value was greater than 0.05. However, significant differences were found between pre-match- post match and post-match- after recovery as the p-values were less than 0.05.

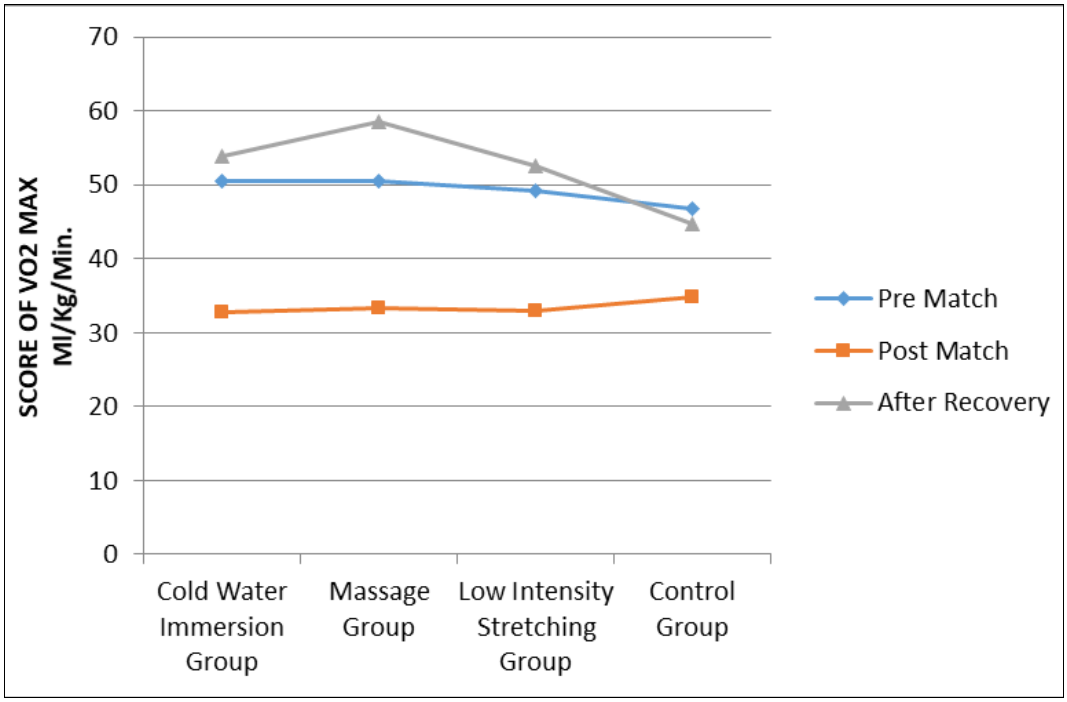

Fig 3: Graphical Representation of vo_2 max of Training Groups through Different Durations of Training

Discussion

Attaining an adequate combination between training and competition load and recovery is very essential for achieving top performance of athletes. Coaches and athletes used a wide range of recovery modalities after the training for proper recovery of the body and to attain balance between training load and recovery. Similarly present study was undertaken to investigate the comparative effect of different recovery programmes on VO2 max

There was a significant effect of recovery durations on three groups (cold water immersion, massage, and control group) VO2max. When asses marginal means of VO2max among recovery durations irrespective of groups of VO2max variable. The marginal mean of vo2 max for overall pre match irrespective of groups (cold water immersion, massage, and low intensity stretching and control group) suggests that its mean score and standard error of mean score were 49.23 and 0.90 respectively. The marginal mean of vo2 max for overall post-match irrespective of groups (cold water immersion, massage, and low intensity stretching and control group) suggests that its mean score and standard error of mean score were 33.49 and 1.33 respectively. The marginal mean of vo2 max for overall after recovery irrespective of groups (cold water immersion, massage, and low intensity stretching and control group) suggests that its mean score and standard error of mean score were 52.44 and 1.78 respectively. It is evident that there was a significant main effect of training duration. To compare different times (i.e., pre match, post- match and after recovery), pairwise comparisons were performed after Bonferroni adjustment.

When asses pairwise comparisons between recovery durations of recovery programme of VO_{2max} variable. Shows that there was a no significant difference were found between pre match and after recovery. However, significant differences were found between pre-match- post match and post -match- after recovery. The significant change was found in VO_{2max}, among basketball players after administration of different recovery programs (Massage, cold water immersion & low intensity stretching recovery programs). It was very clear from the marginal means of VO_{2max} among recovery durations irrespective of groups of VO_{2max} variable, For the fast and better recover of basketball players it was found cold water immersion recovery programme was better than other recovery programme (massage and low intensity stretching). The linear significant was found in VO_2 max among basketball players after administration of different recovery programmes (Massage, Cold water immersion and Low intensity stretching recovery programmes).It may be attributed since the time duration which was 15 minutes appropriate to produce significant change VO2max different recovery programmes. It was very clear from the finding of study, for the fast and better recover of basketball players it was found cold water immersion recovery programme was better for VO_2 max variables among than other recovery programmes (Massage and Low intensity stretching)

A lot of research shows that there is a significant effect on the VO2max changes after the massage treatment in the active and passive recovery groups. Massage could be an additional technique during training or competition. The research suggests that the athlete and the coaches use this combination of recovery techniques, such as massage and jogging, for a fast and accurate recovery, active recovery with massage has a higher improvement on the maximal endurance capacity (VO2MAX) of volleyball athlete PBVSI Sumenep (5,19%) (Helaprahara, D., & Arisetiawan, R. E. 2019) [3]. It is relevant with the research involving different subjects conducted by (Musrifin & Bausad, 2013) [7] that was aimed at measuring the effect of sport massage as a passive recovery in improving the maximum capacity of endurance (VO2MAX) of futsal athlete of IKIP Mataram. The sport massage as a passive recovery is better than the active recovery in improving VO2Max of futsal athlete of IKIP Mataram, 10,37 % (The

Experiment Group, received sport massage method as a passive recovery) and 6,57 % (Control Group, received free movement active recovery). It is also in line with the result of the study of (Kurniawan & Elfarabi, 2018) [6], which shows that active recovery and the recovery combination could reduce the level of fatigue of football athletes. The finding of present study suggests that performance of cold-water immersion as a recovery procedure following exercise is better than performing no recovery procedure therefore, athletes, coaches and sports trainers should implement cold-water immersion post-exercise irrespective of the time of administration. Where possible, cold-water immersion should be performed immediately post-exercise to gain maximal recovery benefits. The result of this research is expected to be implemented in training or competition as an alternative recovery to decrease the level of fatigue of various team and individual athletes.

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