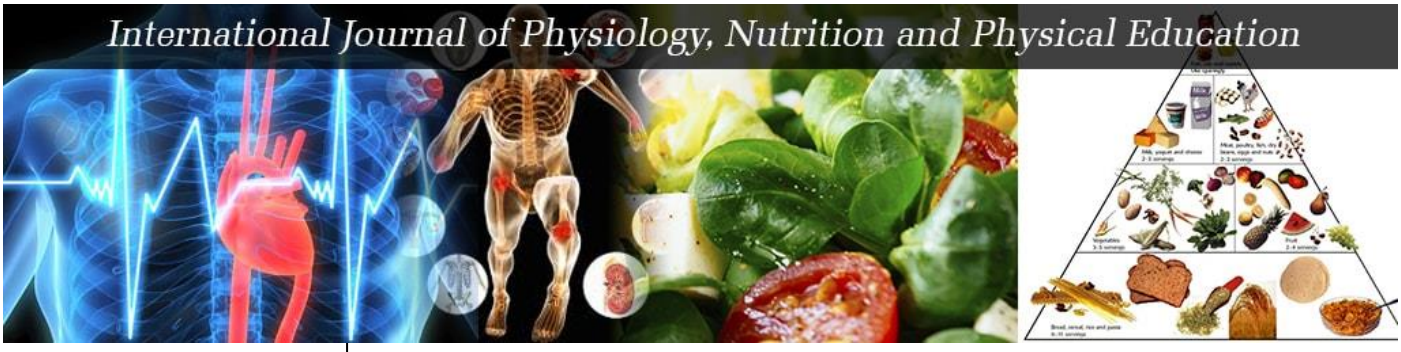

ISSN: 2456-0057
IJPNPE 2023; 8(1): 240-245

www.journalofsports.com
Received: 13-12-2022
Accepted: 30-01-2023

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Effect of different recovery methods on heart rate of junior medium fast bowlers

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Abstract
The increased level of competitiveness in sports has had a positive effect on the quality of rehabilitation facilities. The effects of active recovery, passive recovery, a contrast bath, and cryotherapy on heart rate at varying intervals were examined and investigated. For the purpose of this study forty (N=20, 5 subjects for each recovery methodology) male medium pacers were selected for study and given a selected load of repetitive 200-meter exercise. Repeated Measure Analysis of variance (R-ANOVA) was employed to determine significant difference at 0.05 level of significance in SPSS 20.0 Different recovery procedures affected heart rate in this research. The contrast bath therapy after the sixth and ninth minute was the most effective treatment for reducing the number of heart beats per minute, active recovery and passive recovery were the next most effective treatments. The findings of this study suggested coaches should organise contrast bath recovery therapy sessions for better recovery of medium fast bowlers.

Keywords: Contrast bath, active & passive, cryotherapy, recovery and cricket

Introduction
The pace at which the heart beats, often known as the heart rate (HR), is a physiological measure of the condition of the circulatory system. An increase in HR is almost always indicative of a rise in the demand for blood from a specific organ or a number of organs. Historically, HR has been used to assess the amount of work demand present across a variety of activities. There have been a number of research works published on the subject of HR in the fields of physical education and sports science. These works cover a wide range of topics. The vast majority of these researchers have made at least one effort to reduce either the level of work intensity or the amount of work. Unless the HR that is supposed to be resting is known, assessing workload through HR changes can be deceiving. (Biswas, 2018) [1]. The physiological needs of cricket, especially during first class matches, have not been well studied. When creating individual training plans, it helps to be aware of the specific physiological demands made on players during game play. The physical demands of an activity are related to the intensity of the exercise, and measuring heart rate (HR) while playing a match is an easy approach to determine the exercise intensity with objectivity. (Nicholson, Gareth & Cooke, Carlton & O'Hara, John & Schonfeld, 2009) [6]. Heart rate rises during dynamic exercise as a result of both enhanced sympathetic activity and parasympathetic withdrawal (Iellamo F., 2001) [4]. Exercise intensity affects the relative importance of the two drives (Hedelin, R., Bjerle, P., & Henriksson-Larsen, 2001) [3]. Bowling-related heart rate rises reflect severe cardio-vascular stress throughout the bowling session. Though blood lactate increases, no considerable buildup occurs, indicating the anaerobic metabolic system plays a minor role in the bowling event(s). High-intensity bowling's total length, between-over recuperation, and intermittent nature may explain the latter result, although the reasons and exact indicators of tiredness are unknown. Noakes and Durrandt (2000) challenged the theoretical idea of physiological tiredness processes in cricket and said the "traditional theories" of cardiovascular-anaerobic energy depletion and energy supply depletion do not explain cricket fatigue. Fast bowlers undergo frequent high intensity acceleration-deceleration (eccentric muscle action) episodes, which might lead to particular muscular fatigue owing to altered muscle action, recruitment, and firing, which may relate to the loss of elastic energy element within muscle.

Post-bowling, elevated levels of muscle injury (creatine kinase) and inflammation (C-reactive protein) have been documented, however this biochemical data is preliminary. Without further evidence, fast bowler tiredness remains hypothetical. (Johnstone *et al*., 2014) [5]. After the training phase is finished, coaches and athletes often start proactive recovery strategies including cryotherapy, massage, contrast bath immersion, stretching, oxygen intake, and garment compression to hasten the recovery process. There are many well-liked recovery techniques being employed by athletes and coaches to hasten athletes' recovery. The use of these therapies for recovery will depend on the kind of activity that must be completed, such as a training session or any competition. Therefore, it is important to research various recovery strategies and their effects on muscle fatigue, recovery, and performance. The following means and method of recovery were selected for the study.

1. Cold-water Immersion
2. Contrast-water Immersion
3. Active Recovery
4. Passive Recovery

The objective of the study was to evaluate the efficacy of various recovery approaches (i.e., active recovery, passive recovery, contrast bath, and cryotherapy) based on a chosen physiological marker (i.e., Heart rate) of recovery at varying time intervals.

Methodology

Selection of Subject

Twenty (N=20) male medium pacers from the different cricket academies were selected as the subjects for this study. Medium pacers age was in between 15-17 years.

Study Design

In order to achieve the objective of the study, the scholar conducted repeated measure experiment to determine the best recovery method for selected junior medium fast bowlers. For this, selected subjected were divided into four different recovery methodology group with 5 subjects in each group.

1. Administration of Heart rate test

- **Purpose:** To measure the number of contractions of heart.
- **Equipment:** Heart Rate Monitor
- **Procedure:** The pressure cuff was wrapped snugly around the mid humerus. The elbow was placed at such position that the pressure cuff was at the same height as the heart. Hands were relaxed with the palm facing up. The start/stop button was pressured. The moment the measuring blood pressure symbol flashed on the display; the air pressure automatically pumped up to 195 mmHg. Then it automatically started decreasing in order to detect heart rate. The detected heart beat lasted on the display for one minute. No talking and moving was permitted.
- **Scoring:** The heart rate was recorded in beats per minute.

2. Administration of Training Load

- **Purpose:** To disturb the normal homeostasis of the body (Singh Hardyal, 1991) [7].
- **Equipment's:** 200 Meter Track, Stop Watch and Stethoscope
- **Procedure:** The subjects were asked to stand behind the restraining line. The subjects performed 3 sets with 5 repetitions of 200 meter at 90% load intensity with 90 seconds rest in between the two sets. (Clark M, Lucett S, McGill E, 2018) [2].

Administration of Recovery Methodology

S. No.	Intervention	Time	Details
1.	Cold-Water Immersion	20 Minutes	Immersion of body till neck in cold with temperature at 10 to 15 ° Celsius
2.	Contrast Water Immersion	20 Minutes	Immersion of body till neck in cold and hot water. Cold Temperature- 15 ° Celsius Hot Temperature- 38 ° Celsius
3.	Active Recovery	20 Minutes	5-minute slow jogging followed by static stretching of major muscles.
4.	Passive Recovery	-	No treatment will be given

Fig 1: Intervention schedule

Statistical analysis

Descriptive statistics and Repeated Measure Analysis of Variance (R-ANOVA) was used in IBM SPSS 20.0 to analyze the comparison of different recovery methodologies (i.e., Active Recovery, Passive Recovery, Contrast Bath and Cryotherapy) on the basis of selected physiological markers i.e., Heart Rate of recovery at different time intervals. (Verma J P, 2013) [8].

Result

Table 1: Descriptive Statistics of Physiological Marker i.e., Heart Rate for different selected recovery methods at different intervals of testing at different intervals of testing

Timing of Test for Heart Rate	Intervention given for recovery	Mean (Beats per minute)	Std. Deviation
Pre-test before load intervention	Active Recovery	88.8000	2.16795
	Cryotherapy Ice Bath Method	91.2000	3.27109
	Contrast Bath	88.2000	3.63318
	Passive Recovery	91.8000	2.86356
Post-test after load intervention	Active Recovery	179.6000	4.03733
	Cryotherapy Ice Bath Method	175.6000	8.90505
	Contrast Bath	181.4000	4.50555
	Passive Recovery	163.0000	8.18535
Test after 3 minutes of intervention	Active Recovery	139.6000	4.03733
	Cryotherapy Ice Bath Method	145.6000	19.47563
	Contrast Bath	139.4000	10.35857
	Passive Recovery	137.0000	9.59166
Test after 6 minutes of intervention	Active Recovery	113.8000	16.36154
	Cryotherapy Ice Bath Method	113.6000	7.23187
	Contrast Bath	96.2000	1.30384
	Passive Recovery	108.2000	6.18061
Test after 9 minutes of intervention	Active Recovery	91.4000	1.14018
	Cryotherapy Ice Bath Method	98.2000	1.09545
	Contrast Bath	87.4000	4.72229
	Passive Recovery	94.4000	1.14018

Table No. 1: - Descriptive Statistics of Physiological Marker i.e., Heart Rate for different selected recovery methods at different intervals of testing at different intervals of testing.

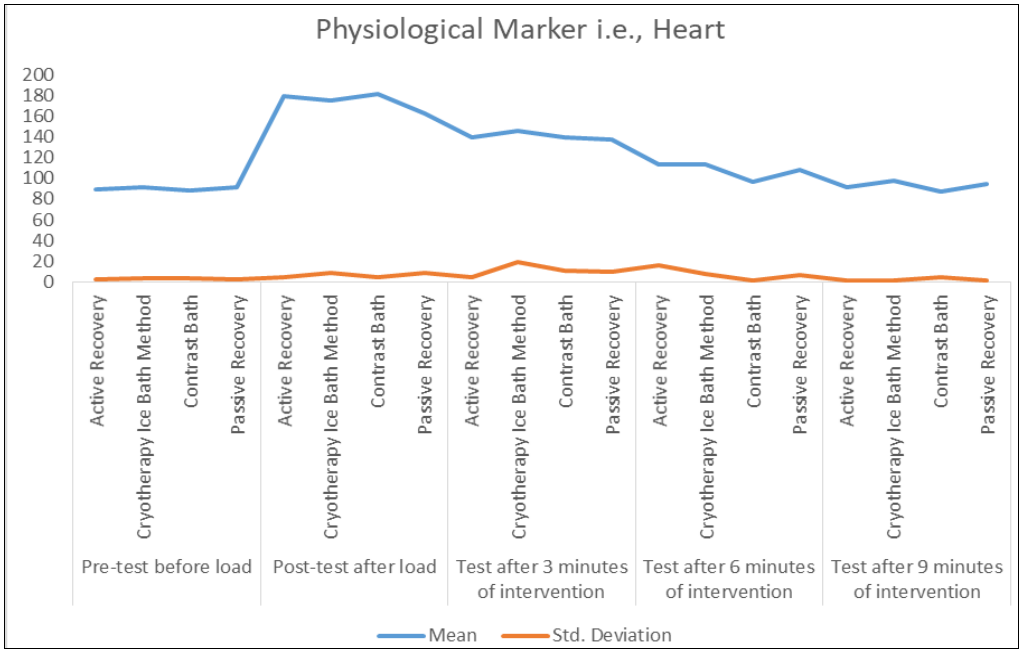

Fig 1: Bar chart for descriptive statistics of Physiological Marker i.e., Heart Rate for different selected recovery methods at different intervals of testing.

Table and Fig No. 1 represents the descriptive statistics i.e., mean and standard deviation of Heart rate before and after recovery method intervention at different time intervals of testing. Heart rate measurement at pre-test before load intervention for active recovery group, cryotherapy ice bath group, contrast bath group and passive recovery group was 88.8±2.16 bpm, 91.20±3.27 bpm, 88.20±3.63 bpm and 91.80±2.86 bpm respectively. Heart rate measurement at post-test after load intervention for active recovery group, cryotherapy ice bath group, contrast bath group and passive recovery group was 179.60±4.03 bpm, 175.60±8.90, 181.40±4.50 bpm and 163±8.18 bpm respectively. Heart rate measurement at post-test after 3 minutes of intervention for active recovery group, cryotherapy ice bath group, contrast bath group and passive recovery group was 139.60±4.03 bpm, 145.60±19.47 bpm, 139.40±10.35 bpm and 137±9.59 bpm respectively. Heart rate measurement at post-test after 6 minutes of intervention for active recovery group, cryotherapy ice bath group, contrast bath group and passive recovery group was 113.80±16.36 bpm, 113.6±7.23bpm, 96.20±1.30 bpm, and 108.20±6.18 bpm respectively. Heart rate measurement at post-test after 9 minutes of intervention for active recovery group, cryotherapy ice bath group, contrast bath group and passive recovery group was 91.40±1.14 bpm, 98.20±1.09bpm, 87.40±4.72 bpm and 94.40±1.14 bpm respectively.

Table 2: Levene's Test of Equality of Error Variances for Physiological Marker i.e., Heart Rate at different intervals of testing

	F	DF 1	DF 2	Sig.
Pre-test before load	.158	3	16	.923
Post-test after load	1.627	3	16	.223
Test after 3 minutes of intervention	1.938	3	16	.164
Test after 6 minutes of intervention	3.045	3	16	.059
Test after 9 minutes of intervention	3.000	3	16	.062
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.				
a. Design: Intercept + Recovery Method Within Subjects Design: Tests				

Table 2 represents the value of Levens test. The Levens is an assumption for R-ANOVA test for determining homogeneity of group. The obtained value for Levens test is 0.923, 0.233, 0.164, 0.059 and 0.062 which is more than 0.05 and hence the assumption of equality of variance is not violated.

Thus the null hypothesis of equality of population means of four treatment groups is rejected and it may be concluded that the recovery performance of selected treatment groups are different at different interval of testing.

Table 3: Mauchly's test of sphericity for selected Recovery Method

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	DF	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Tests	.125	29.926	9	.000	.615	.872	.250
Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.							
a. Design: Intercept + Recovery Method, Within Subjects Design: Tests							
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.							

Table No. 3 represents the Mauchly test of sphericity which tests the assumptions of variability across the repeated measure design. The obtained value was significant as p-value less than 0.05, hence assumption of sphericity was violated. In order to adjust the sphericity assumption Epsilon was noted for Greenhouse-Geisser (epsilon less than 0.75) as correction model.

Table 4: Tests of within-subjects' effects for recovery patterns, test points and their interaction on heart rate recovery

Source		Type III Sum of Squares	DF	Mean Square	F	Sig.	Partial Eta Squared
Tests	Sphericity Assumed	104101.060	4	26025.265	512.750	.000	.970
	Greenhouse-Geisser	104101.060	2.462	42288.504	512.750	.000	.970
	Huynh-Feldt	104101.060	3.489	29837.839	512.750	.000	.970
	Lower-bound	104101.060	1.000	104101.060	512.750	.000	.970
Tests* Recovery Method	Sphericity Assumed	1918.540	12	159.878	3.150	.001	.371
	Greenhouse-Geisser	1918.540	7.385	259.787	3.150	.009	.371
	Huynh-Feldt	1918.540	10.467	183.300	3.150	.003	.371
	Lower-bound	1918.540	3.000	639.513	3.150	.054	.371
Error (Tests)	Sphericity Assumed	3248.400	64	50.756			
	Greenhouse-Geisser	3248.400	39.387	82.474			
	Huynh-Feldt	3248.400	55.822	58.192			
	Lower-bound	3248.400	16.000	203.025			

From table no. 4 it was evident that there was significant difference obtained for main effect of time of testing on heart rate as obtained Greenhouse-Geisser p-value is less than 0.05 with partial eta square of 0.97 which means the variation in heart rate is 97% explained by time interval of testing. For interaction effect of time and recovery methodology on heart rate as obtained Greenhouse-Geisser p-value is less than 0.05 with partial eta square of 0.371% which means the variation in heart rate is 37.1% explained by time interval of testing and recovery method together. Hence, pairwise comparison was done to determine significance of difference between the group and within the group at different time intervals of testing.

Table 5: Pairwise comparisons between overall recovery patterns of heart rate recovery

(I) Intervention given for recovery	(J) Intervention given for recovery	Mean Difference (I-J)	Std. Error	Sig.
Active Recovery	Cryotherapy Ice Bath Method	-2.200	2.787	1.000
	Contrast Bath	4.120	2.787	.953
	Passive Recovery	3.760	2.787	1.000
Cryotherapy Ice Bath Method	Active Recovery	2.200	2.787	1.000
	Contrast Bath	6.320	2.787	.225
	Passive Recovery	5.960	2.787	.290
Contrast Bath	Active Recovery	-4.120	2.787	.953
	Cryotherapy Ice Bath Method	-6.320	2.787	.225
	Passive Recovery	-.360	2.787	1.000
Passive Recovery	Active Recovery	-3.760	2.787	1.000
	Cryotherapy Ice Bath Method	-5.960	2.787	.290
	Contrast Bath	.360	2.787	1.000

From table no. 5 it can be concluded the there was no overall significant difference was obtained for selected recovery methodology. As all the values obtained for pairwise comparison were more than 0.05 (p>0.05). Hence, there was no significant difference for heart rate was founded for selected recovery methodology.

Table 6: Pairwise comparisons between overall times intervals of testing of heart rate recovery

(I) Tests	(J) Tests	Mean Difference (I-J)	Std. Error	Sig.[b]
Pre-test before load	post-test after load	-84.900*	1.610	.000
	Test after 3 minutes of intervention	-50.400*	2.918	.000
	Test after 6 minutes of intervention	-17.950*	2.245	.000
	Test after 9 minutes of intervention	-2.850*	.705	.009
post-test after load	pre-test before load	84.900*	1.610	.000
	Test after 3 minutes of intervention	34.500*	2.372	.000
	Test after 6 minutes of intervention	66.950*	2.098	.000
	Test after 9 minutes of intervention	82.050*	1.689	.000
Test after 3 minutes of intervention	pre-test before load	50.400*	2.918	.000
	post-test after load	-34.500*	2.372	.000
	Test after 6 minutes of intervention	32.450*	2.862	.000
	Test after 9 minutes of intervention	47.550*	2.877	.000
Test after 6 minutes of intervention	pre-test before load	17.950*	2.245	.000
	post-test after load	-66.950*	2.098	.000
	Test after 3 minutes of intervention	-32.450*	2.862	.000
	Test after 9 minutes of intervention	15.100*	2.182	.000
Test after 9 minutes of intervention	pre-test before load	2.850*	.705	.009
	post-test after load	-82.050*	1.689	.000
	Test after 3 minutes of intervention	-47.550*	2.877	.000
	Test after 6 minutes of intervention	-15.100*	2.182	.000
Based on estimated marginal means				
*. The mean difference is significant at the .05 level.				

From table no. 6 it can be concluded the there was overall significant difference was obtained for selected time intervals. As all the values obtained for pairwise comparison were less than 0.05 (p<0.05). Heart rate at different intervals do have significant difference among them as mean difference between 9 minutes and pre-test was having least significant difference (p-value 0.009, Mean diff. 2.850). The difference between post-test after load and after 9 minute of intervention was having highest significant difference (p-value 0.00, Mean Diff. 82.05).

The difference between post-test 3 minutes and after 9 minute of intervention was having moderate significant difference (p-value 0.00, Mean Diff. 47.55).

The difference between post-test 6 minutes and after 9 minute of intervention was having least significant difference (p-value 0.00, Mean Diff. 15.10). Hence it can be concluded from this table that selected load do increased the heart rate and heart rate was decreased to initial state in selected course of time.

Table 7: Pairwise comparison for selected recovery patterns at 3, 6- and 9-minutes posttest reading of heart rate

Tests	(I) Intervention given for recovery	(J) Intervention given for recovery	Mean Difference (I-J)	Std. Error	Sig.
Test after 3 minutes of intervention	Active Recovery	Cryotherapy Ice Bath Method	-6.000	7.713	.448
		Contrast Bath	.200	7.713	.980
		Passive Recovery	2.600	7.713	.740
	Cryotherapy Ice Bath Method	Active Recovery	6.000	7.713	.448
		Contrast Bath	6.200	7.713	.433
		Passive Recovery	8.600	7.713	.281
	Contrast Bath	Active Recovery	-.200	7.713	.980
		Cryotherapy Ice Bath Method	-6.200	7.713	.433
		Passive Recovery	2.400	7.713	.760
	Passive Recovery	Active Recovery	-2.600	7.713	.740
		Cryotherapy Ice Bath Method	-8.600	7.713	.281
		Contrast Bath	-2.400	7.713	.760
Test after 6 minutes of intervention	Active Recovery	Cryotherapy Ice Bath Method	.200	5.999	.974
		Contrast Bath	17.600*	5.999	.010
		Passive Recovery	5.600	5.999	.364
	Cryotherapy Ice Bath Method	Active Recovery	-.200	5.999	.974
		Contrast Bath	17.400*	5.999	.010
		Passive Recovery	5.400	5.999	.381
	Contrast Bath	Active Recovery	-17.600*	5.999	.010
		Cryotherapy Ice Bath Method	-17.400*	5.999	.010
		Passive Recovery	-12.000	5.999	.063
	Passive Recovery	Active Recovery	-5.600	5.999	.364
		Cryotherapy Ice Bath Method	-5.400	5.999	.381
		Contrast Bath	12.000	5.999	.063

Test after 9 minutes of intervention	Active Recovery	Cryotherapy Ice Bath Method	-6.800*	1.616	.001
		Contrast Bath	4.000*	1.616	.025
		Passive Recovery	-3.000	1.616	.082
	Cryotherapy Ice Bath Method	Active Recovery	6.800*	1.616	.001
		Contrast Bath	10.800*	1.616	.000
		Passive Recovery	3.800*	1.616	.032
	Contrast Bath	Active Recovery	-4.000*	1.616	.025
		Cryotherapy Ice Bath Method	-10.800*	1.616	.000
		Passive Recovery	-7.000*	1.616	.001
	Passive Recovery	Active Recovery	3.000	1.616	.082
		Cryotherapy Ice Bath Method	-3.800*	1.616	.032
		Contrast Bath	7.000*	1.616	.001

In the table above i.e., 4.10 recovery methods were compared at selected time intervals of interval i.e., 3rd, 6th and 9th minute. Results of pairwise comparison of selected recovery methodologies at Test after 3 minutes of intervention doesn't have significant difference as obtained p- value was more than 0.05 (p>0.05) Results of pairwise comparison of selected recovery methodologies at Test after 6 minutes of intervention have significant difference between contrast bath therapy and active recovery and cryotherapy as obtained p- value was less than 0.05 (p<0.05 Mean diff. 17.6 & 17.4) Results of pairwise comparison of selected recovery methodologies at Test after 9 minutes of intervention have significant difference between contrast bath therapy and active recovery, passive recovery and cryotherapy as obtained p- value was less than 0.05 (*p*<0.05 Mean diff. 4, 10.8 & 7).

Discussion on findings

The result for the study further revealed that selected training was enough capable to increase the maximum heart rate of the subject up to 220 beats per minute. The contrast bath therapy after 6th and 9th minute, was the most effective treatment for lowering heartbeats per minute followed by active recovery and passive recovery. According to the results in Table No. 4.7, the estimated effect size, or partial eta square, is 0.037, which suggests that only 37% of the variation is explained. In other words, only 37% of the change in the dependent recovery marker-heart rate - can be attributable to specific techniques of recovery. This result of study was similar to results produced by (Wilcock, I. M., Cronin, J. B., & Hing, 2006) [9]. Because the vasoconstriction and vasodilatation mechanism in hot and cold water facilitates the rapid supply of blood in needing muscles, intracellular intravascular fluid shifts, reduction of muscle oedema, and also increases cardiac output without increasing energy expenditure, contrast bath was effective in promoting heart rate recovery.

Conclusion

This study discovered significant effect of different recovery methods on heart rate. According to the findings of the present investigation, the contrast bath therapy after the sixth and ninth minute was the most effective treatment for reducing the number of heart beats per minute, active recovery and passive recovery were the next most effective treatments. The findings of this study suggested coaches should organise contrast bath recovery therapy sessions for better recovery of medium fast bowlers.

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