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Cold Water Immersion: A Foe for Immediate Leg Strength Recovery Post Strenuous Activity

Supriyo Mondal [1*], Ashok Kumar Goon [2], Chandan Ghosh [3]
1, Ph.D. Scholar, Lakshmibai National Institute of Physical Education, Gwalior, Madhya Pradesh, India
2, Associate Professor, HOD, Department of Physical Education, Visva Bharati, W.B., India
3, Ph.D. Scholar, Dept. of Physical Education, Visva Bharati, W.B., India
* Email of the corresponding author: supriyomondal25@gmail.com

Abstract
Recovery post sport activities of demanding nature has become a matter of great concern in present days. To add information in the knowledge bank regarding the rate and trend in lower limbs tiredness recovery due to cold water immersion (CWI) after strenuous workout present research in a highly controlled manner was conducted. Ten participants of equal caliber were selected purposively for the experiment. They ran at Target Heart Rate Zone of 80%-90% of their Maximum Heart Rate for 20 minutes, and had a session of idle CWI (20˚C) post activity for 30 minutes. Isometric Leg Strength Test and Sergeant Jump Test were conducted pre activity, post activity and post CWI for availing data. Descriptive statistics, rANOVA and bonferroni post hoc test were employed using IBM SPSS-17. Level of significance choosen was 0.05. Significant decreased state of post workout readings were observed in both the cases. Further post recovery no improvement in state of lower limbs isometric strength was found, whereas decrease in explosive leg strength was evident. Thus it can be concluded that instead of being friend CWI is a foe for immediate leg strength recovery. In future more research having different and prolonged observation points can be framed to have clear idea on this issue.
Keywords: Sports, Recovery, Cold Water Immersion, Isometric Leg Strength, Explosive Leg Strength.

I. Introduction

Background: A firm amount of muscular strength is precondition for any short of human movement [1] as the body lever is made up of mainly bones and muscles. The force for functioning of this lever is generated by none other than muscles involved in that particular movement. Owing to these reasons strength is one of the most contributing factors for success in sport involving high level of competition. Most of the sporting movements demanding immediate and powerful force production, utilizes the lower limbs for the purpose, resulting in huge deposit of metabolic waste within the lower limbs due to insufficient presence and utilization of oxygen, disturbances in production of K^+ and other factors [2]. A diminished transsarcolemmal K+ gradient per se can reduce maximal force in non-fatigued muscle suggesting that K+ causes fatigue. Changed transsarcolemmal Na+, Ca2+, Cl− and H+ gradients are insufficient by themselves to cause much fatigue but each ion can interact with K+ effects [3], [4]. Sport scientists are in constant quest of finding new and effective means and methods for promoting desired recovery as soon as possible. Water as a medium has added benefit for promotion of physiological as well as psychological recovery after taxing workout. Researches on cold water immersion [5], hot water shower [6], hot-cold alternate immersion [7], active recovery in water [8] etc. are in current trends for this decay. The researcher after reviewing literature have found controversial debate [9] regarding the usefulness of passive cold water immersion in real sense, thus to add in this information bank present research in a highly controlled manner was conducted.

Purpose: Grounds behind conducting this study was to know the rate and trend in lower limbs tiredness recovery due to cold water immersion (CWI) after strenuous workout, as it may help to aid information in the area of sport recovery for planning training and further researches in future.

II. Methodology

Participants: Ten athletes from LNIPE, Gwalior were selected for this research. They had almost similar anthropometric measurements, physiological capacity, chronological age (18-19 year), training age (5-6 year), and event (sprinting in track and field) etc. residing in same campus, again they had similar daily routine.

Criterion Measures: Leg strength was selected to be studied at different time interval with the help of two widely accepted tests i.e. Sergeant Jump Test [10], [11] and Isometric Leg Strength Test [12], [13].

Administration of the Experiment: The experiment was conducted in the fitness center of LNIPE, Gwalior having controlled temperature (28˚C) inside A/C fitness centre during the month of August and September, 2013. Equipments used were Treadmill (FreeMotion co.), Heart Rate Monitor Watch (Garmin Forerunner), Jacuzzi Tub for CWI, Room Temperature Thermometer (Omsons), Portable Leg Dynamometer etc. The participants were informed about the pros and cons of experiment to be conducted in detail and their willing concern was taken on paper. The experiment started with a mild warm up session consisting of self stretching. The treadmill intensity was manipulated in a slow progression manner to such that the heart rate remained within the Target Heart Rate Zone(THR) of 80%-90% of their Maximum Heart Rate [14] ($HR_{max} = 208 - (0.7 \times age)$) for at least

16 minutes of the total 20 minutes of duration during treadmill workout. The well established Karvonen formula [15] (THR = ((HR_{max} − HR_{rest}) × % intensity) + HR_{rest}) for calculating target heart rate was used. Participants were free to withdraw themselves at any point of workout. Best of two readings on leg strength of both the test were taken at regular interval just before workout, just after workout and 30 minutes after workout. Post recovery till the last reading the participants kept sitting inside the Jacuzzi tub having water cooled to 20˚C up to the waist level and kept sitting idle for 30 minutes [16]-[18].

Statistical Technique: The study followed repeated measure design. For analyzing the obtained data and developing meaningful information from it descriptive statistics, one way repeated measure analysis of variance (rANOVA) and bonferroni post hoc test was conducted using IBM SPSS-17 software [19]. Level of significance choosen was 0.05.

III. Results and findings

Table 1: **Descriptive Statistics of Leg Strength**

Reading at Different Time	Isometric Leg Strength Test			Explosive Leg Strength Test		
	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error
Leg Strength Pre Activity	178.90	18.83	5.95	58.50	7.37	2.33
Leg Strength Post Activity	163.10	17.82	5.64	52.10	8.56	2.71
Leg Strength Post Recovery	155.90	16.60	5.25	45.10	8.03	2.54

Table 1 indicates descriptive scores of mean, standard deviation & standard error of mean of Isometric Leg Strength Test & Sergeant Jump Test of the participants.

Table 2: **Mauchly's Test for Testing Assumption of Sphericity**

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	P-Value	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Isometric Strength	0.40	7.26	2	.027	0.63	0.68	0.50
Explosive Strength	0.36	8.15	2	.017	0.61	0.66	0.50

*Significant at 0.05 level.

Results of table 2 shows that in both the case assumption of sphericity has been violated as Mauchly's Test of Sphericity are significant having P-Values less than 0.05. As the Epsilon value is less than 0.75 thus Greenhouse-Geisser correction will be used for referring significance of the F ratio for interpreting results in rest of the study.

Table 3: **Within-Subjects Effects of Leg Strength Tests**

Tests		Sum of Squares	df	Mean Square	F	P-Value	Partial Eta^2
Isometric Leg Strength	Greenhouse-Geisser	2768.27	1.25	2209.59	11.90*	.004	0.57
Error(Isometric Leg Strength)	Greenhouse-Geisser	2094.40	18.00	116.36			
Explosive leg Strength	Greenhouse-Geisser	898.40	1.22	736.29	42.65*	.000	0.83
Error(Explosive leg Strength)	Greenhouse-Geisser	189.60	10.98	17.27			

*Significant at 0.05 level.

In Table 3, as the P-Value in the first case is 0.004 and in the later case is 0.000 both of which is less than the criterion value of 0.05 statistical significant differences is present in both the cases. We can, therefore, conclude that there was a significant difference between the leg strength readings at different time point calculated by Isometric Leg Strength Test and Sergeant Jump Test. To know in between which readings the difference actually existed, Bonferroni post Hoc test was conducted. Further effect size of the rANOVA for isometric leg strength and explosive leg strength were impressive i.e. 57 % & 83 % respectively.

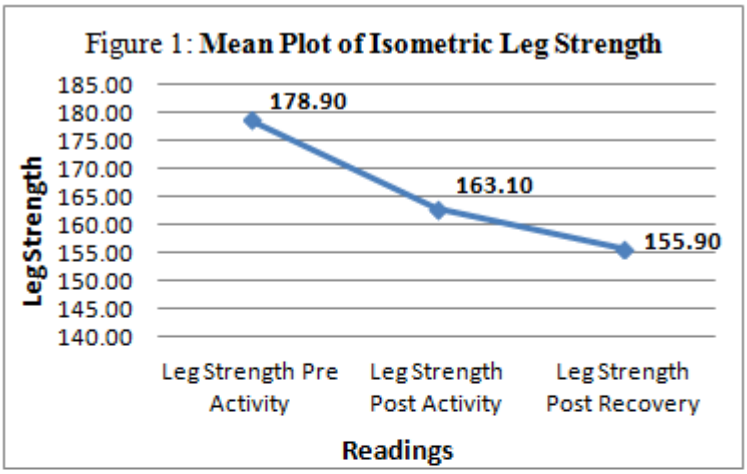
Table 4: **Pairwise Comparisons of Marginal Leg Strength Means**

Tests	Leg Strength (I)	Leg Strength (J)	Mean Difference (I-J)	Std. Error	P-Value	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Isometric Leg Strength	Pre Activity	Post Activity	15.80*	2.35	.000	8.92	22.68
	Pre Activity	Post Recovery	23.00*	5.46	.007	6.99	39.01
	Post activity	Post Recovery	7.20	5.87	.754	-10.03	24.43
Explosive leg Strength	Pre Activity	Post Activity	6.40*	0.76	.000	4.67	8.13
	Pre Activity	Post Recovery	13.40*	1.50	.000	10.01	16.79
	Post activity	Post Recovery	7.00*	1.87	.005	2.77	11.23

* Significant at 0.05 level

The rows having mean difference followed by star (*) in the above Table 4 indicates the presence of significant difference between various reading points of both the leg strength test. Except post activity to post recovery for isometric leg strength all other pairs confirm difference to be present within them.

IV. Discussion of findings



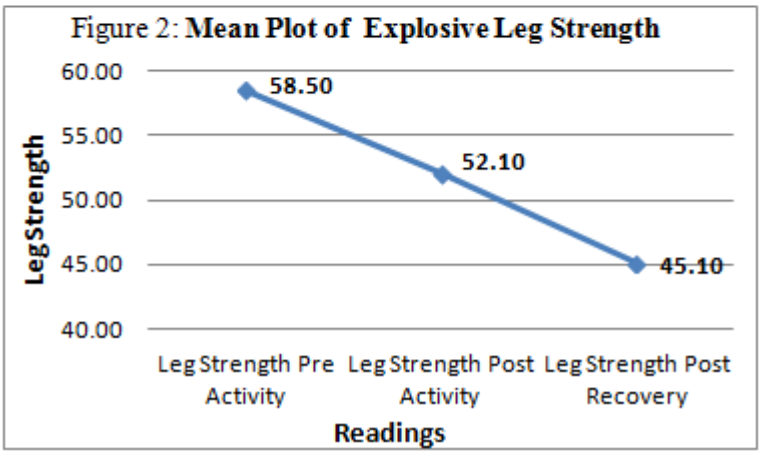


Figure 1 illustrates the trend of lower limb tiredness after strenuous workout followed by CWI in respect to isometric leg strength. It shows a decrease level of performance after 20 minutes of workout as well as after CWI for 30 minutes. Referred to Table 4 it is evident that a statistical significant different lie only between the first two readings, for later pair difference is not statistically significant. Thus we may conclude that workout caused tired leg causing reduced isometric strength but CWI session had no impact on recovery from it.

Figure 2 illustrate the trend of lower limb tiredness after strenuous workout followed by CWI in concern to explosive strength. It too shows a diminishing trend and is statistically significant in reference to table 4 between all the readings. It shows that CWI added more reduced level of explosive strength instead of increasing level of

explosive strength. This may be due to immediate exposure to the tests just after being immersed inside the cold water for a reasonably long time [20]. The subjects were enough warmed up before the previous two readings, but here they were rather cooled down [21]. Qualitative assessment of the participants disclosed they were relaxed, felt well, and self reported satisfied recovery. Might be if the study would have considered few more readings after couple of hours and so on than results would have been different. Earlier Mondal and Sarkar (2013) [22] investigated the rate and trend of tiredness of lower limbs after strenuous workout followed by a passive recovery, it was found both isometric leg strength and explosive leg strength did not recovered significantly till 30 minutes post workout. Recently similar result, further decrease in explosive strength post similar treadmill workout protocol due to Jacuzzi bath recovery session of 30 minutes were reported by Mondal et al. [23]earlier in this year.

V. Conclusion

In both the tests Isometric Leg Strength Test and Sergeant Jump Test for assessing tiredness of lower limbs after strenuous well controlled workout for 20 minutes we found significant increase state of post workout readings. With passage of time after 30 minutes post CWI recovery there was no improvement in state of lower limbs isometric strength, whereas decrease in explosive leg strength was evident. In future more research having different and prolonged observation points can be framed to have clear idea on this issue and to promote strength recovery during this post recovery period by incorporating other different means, methods, modalities etc.

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