

## Immediate Effect of Cold Water Immersion on Foot and Ankle Muscle Strength and Standing Balance in Young Healthy Individuals: A Clinical Trial

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### ABSTRACT

Cryotherapy minimizes the effects produced by the inflammatory process and aid in recovery with reduction in pain, swelling and muscles spasm. Standing balance is an important factor when considering return to participation, because it demonstrates the function of lower limb. Lower limb muscle plays an important role in day living task (walking, chair rise, climbing stairs etc.) Among the lower limb joints ankle deserve the special attention as plantar / dorsi flexion, inversion and eversion are key movements for balance and general functional ability. In previous studies state the varied opinions on effect of cold water immersion on lower limb muscle strength and its effect on standing balance. Cold immersion, immediate effects had not yet evaluated on foot muscle strength as well as standing balance. Thus, aim to find out immediate effect of cold water immersion on ankle muscle strength and standing balance in healthy individuals using Jammer Hand Held Dynamometer.

**Materials and methodology:** Permission was obtained from the institutional and ethical committee and total 50 (25 males, 25 females) normal healthy individuals between age 18 to 25 years who were willing to participate included in study by convenient sampling method. Single leg stance test (SLST) which is a valid and reliable tool, use to evaluate static balance in both eye open and eyes closed. To assess ankle muscle strength, Jammer hand held dynamometer which is easy to use and reliable device, was used.

**Data analysis:** Data collection was done and statistical analysis was done by using software 14.0. Paired t-test was used for intra group comparison. Unpaired t-test was used for inter

group comparison of pre and post cold water immersion for balance and ankle muscle strength assessment between males and females. Level of significance 'p' value < 0.001.

**Results:** There is highly significant decrease in strength of ankle plantar/dorsiflexors, invertor and evertor muscles, post cold water immersion bilaterally as well as single leg stance tests showed highly significant diminished static balance score in both eyes open and eyes close conditions (p<0.001) in dominant as well as non dominant leg in both genders.

**Conclusion:** Cold water immersion decrease muscle contractility of foot and ankle muscles and diminish static balance in both genders with eyes open and eyes closed significantly.

**Key Words:** Cold water immersion, cryotherapy, muscle strength, standing balance

### INTRODUCTION

Cooling of muscle tissue has been used for decades to obtain specific therapeutic objectives. [1] Application of cold therapy for cooling include ice cube massage, ice pack, ice immersion, vapo-coolant spray and cold whirlpool which are commonest regime for minor acute musculoskeletal injuries. [2] Cryotherapy has analgesic effect [3] which has also been shown to produce a slowing of motor nerve conduction velocity that results in an inefficiency of the musculo-tendinous unit. [4] Cooling of muscle tissue has been used to obtain alteration of hemodynamics, metabolism, nerve conduction, connective tissue extensibility and pain perception. [1] The alteration of muscle temperature has

also been shown to influence muscles contractile ability. [1] Cold water immersion is known to reduce pain, edema, inflammation, muscle stiffness. [5]

The application of cold increases the pain threshold, tissue viscosity, leads to production of endorphins and testosterone in the body. [6] Cold immersion is a commonly used therapeutic modality for treatment of musculoskeletal and sport injuries. [7] The most common indications and uses for the local application of therapeutic cold modalities include the following i.e. to reduce swelling following trauma, to reduce acute inflammatory reaction, reduces muscle sprain, muscle tear, decrease muscle spasm etc. [8,9] In sport medicine- cold is applied for the treatment of acute and chronic soft tissue injuries [3] and some studies have shown benefits to athletes after both local and whole body cryotherapy. [3,10]

Generally, it is not recommended to return to play immediately after using cryotherapy due to anesthetic effects of the cold. [11, 12] The effect of cold on muscle strength depends on muscle temperature. [2] In few studies increase in strength [4,12] has been reported whereas in some decrease in strength [13,14] has been seen after cold therapy. Though strength can be assessed for all human muscles and due to the important role they play in day living tasks (walking, chair rise, climbing etc.) which may be compromised by neuromotor pathologies and aging [15] hence particular clinical relevance is conferred to the strength of lower limb muscle. Among the lower limb joints ankle deserve a special attention, as plantar/dorsiflexion and inversion and eversion are key moments for balance and general functional ability which play an important role in human gait. [16]

As of today a wide spread and commercially available method to measure muscle strength involves the use of Hand Held Dynamometer (HHD) or isokinetic dynamometer. [17-19] The Hand held dynamometer measures the peak force produced by a muscle as it contracts while pushing against an object. [20] A recent

systematic reviews of HHD for assessment of muscle strength in the clinical setting found the instrument to be a reliable and valid tool (0.84 to 0.99). [21, 22] The most adopted methodology to assess strength involves the use of HHD, which is portable and easy to use device. [15] It consist of a small and portable single-axis dynamometer that can be held in hand by a clinician and applied on some defined landmarks, while asking the patient to exert a force against it (make test). [23]

Single leg stance test (SLST) is reliable and valid test for assessment of standing balance in athletes and young. [24] SLST assesses static balance in both eyes open and eyes close. [25] In a study conducted by Kernozek et al, [24] found that after a twenty minute ice water immersion increase postural sway and still had effects after twenty minutes of post treatment. In investigating dynamic postural control, Minicelo et al [25] found no change after cold water immersion. However, other author found a diminishing effect in dynamic stability after cold water immersion. [26] So, there is diversity in research regarding the effect of cold immersion on balance hence the purpose of this study is to test the immediate effect of cold water immersion on ankle and foot muscles strength using HHD.

## MATERIALS AND METHODOLOGY

Permission was obtained from ethical committee and head of institution for conduction of study. A comparative intervention study was performed at institution on 50 students (25 males, 25 females) of age 18 -25years. The students were selected by purposive convenient sampling method. Students willing to participate were included and consent was obtained.

Students with diagnosed case of any muscular or joint injury to the lower limb in last

6 months duration or any open wounds/skin lesions to lower limbs or any known neurological disorders and obesity with

BMI  $\geq 29.9$  kg/m<sup>2</sup> were excluded from the study.

## PROCEDURE

Permission was obtained from the ethical committee and head of institution. Participants were selected between the age group of 18 to 25 years by the purposive sampling method. Total 50 participants were selected 25 males & 25 females, who were co-operative and willing to participate in study, were included. Written informed consent was obtained from all the participants and detail procedure of the evaluation and importance of the study was explained. Students with diagnosed case of any muscular or joint injury to the lower limb in last six month duration or any open wounds/ skin lesions to lower limbs or any known neurological disorders and obesity with BMI  $\geq 29.9$  kg/m<sup>2</sup>, were excluded from the study. Demographic data like name, age, gender, height (cm), weight (Kgs), BMI (Kg/m<sup>2</sup>) were taken. Dominance of lower limb was checked by kicking the ball. Temperature sensation was evaluated by using 2 test tube (hot water temperature 45°C and cold water temperature 10°C) on both lower limb below knee in all dermatomes. Bilateral range of motion of ankle joint plantar flexion, dorsiflexion, inversion and eversion was checked by using half circle universal goniometer. [27] Balance assessment [2,13] was performed by using single leg stance test-SLST. In balance assessment, the participants stood in the marked position on the floor, with their hands crossed over the shoulder. The subjects lifted their dominant leg to a standard height approximately 10 cm and held it for 10 seconds with both eyes open and eyes close before and after cold water leg immersion. Same procedure was repeated for non-dominant leg. The number of attempts to complete the SLST was also recorded for each participant. Ankle muscle strength [4, 15] was assessed using the 'make test', for plantar flexors, dorsi flexors, invertors and evertors, where the examiner held the Hand Held Dynamometer (HHD)

stationary while the participant actively exerted their maximal force for performing ankle plantar flexion, dorsi flexion, eversion, and inversion respectively. Testing of each muscle group required a contraction of 5-seconds. Three contractions for each muscle group were recorded, and a minimum rest period for 10-seconds between every contraction was given. And the score of best of three contractions was noted. Cold water immersion (at 15°C) of both legs below knee in water container for 20 minutes duration was done. After 20 minutes duration of cold water immersion participants were assessed for balance with eyes open and eyes close, then again foot muscle strength was assessed by HHD for plantar flexion, dorsiflexion, inversion and eversion both sides. Thermometer was used to measure water temperature before and during cold water immersion. Temperature of cold water was checked after every five minutes and was maintained by adding ice cubes accordingly. Mackintosh sheet was used to cover the top of the container to maintain the temperature.

## DATA ANALYSIS

Data collection was done and statistical analysis was done by using software 14.0. Paired t-test was used for intra group comparison. Unpaired t-test was used for inter group comparison of pre and post cold water immersion for balance and strength assessment between males and female. Level of significance 'p' value less than 0.001.

## RESULTS

The result showed that ankle muscle strength reduced significantly after 20 minutes of cold water immersion among both gender on both dominant and non dominant side lower limb in age group of 18-25 years. The mean pre and post cold water immersion ankle muscle strength of dominant side and non dominant side showed highly significant (HS) p values (<0.0001) for plantar flexors, dorsiflexors, invertors and evertors muscles. (Table 1)

**Table 1: Pre and post cold water immersion mean ankle muscle strength in Kilograms on dominant and non-dominant side Lower limb**

Lower limb	Ankle muscles	Pre-Immersion (Kg)	Post-immersion (Kg)	Difference (Kg)	t-value	p-value
Dominant side	PF	17.4 ± 3.16	13.98 ± 2.59	3.42	15.84	0.0001, HS
	DF	13.06 ± 2.75	10.72 ± 2.19	2.34	11.99	0.0001, HS
	INV	10.42 ± 2.77	7.46 ± 1.69	1.96	8.38	0.0001, HS
	EVR	9.16 ± 1.84	7.72 ± 1.62	1.44	10.25	0.0001, HS
Non-dominant side	PF	13.9 ± 2.13	12.20 ± 2.23	1.70	7.31	0.0001, HS
	DF	11.1 ± 1.72	9.48 ± 1.54	1.62	12.40	0.0001, HS
	INV	9.48 ± 2.45	8.06 ± 1.77	1.42	6.35	0.0001, HS
	EVR	8.92 ± 2.31	7.26 ± 1.45	1.66	8.08	0.0001, HS

PF-Plantar flexors, DF- Dorsi flexors, INV- Invertors, EVR- Evertors, HS- Highly significant ( $p < 0.001$ )

**Table 2: Comparison of Pre and post cold immersion ankle muscle strength between male and female for both dominant and non-dominant side**

	Dominant side ankle Muscle strength (Kgs)		Non-Dominant side ankle Muscle strength (Kgs)	
	Female	Male	Female	Male
Pre cold immersion	11.61 ± 1.73	13.41 ± 2.59	10.25 ± 1.50	11.45 ± 1.95
Post cold immersion	9.46 ± 1.46	10.98 ± 1.86	8.59 ± 1.17	9.91 ± 1.66
P value	0.0059, HS	0.0025, HS	0.0188, S	0.0022, HS

S- Significant ( $p < 0.05$ ), HS-Highly Significant ( $p < 0.001$ )

In present study, it was found that ankle muscle strength reduced among both genders after cold immersion when compared to pre immersion ankle muscle strength values in dominant as well as non dominant side lower limb.(Table 2)

**Table 3: Number of attempts during Single Leg Stance Test (SLST) with eyes open and eyes close with Pre and post cold immersion on dominant side lower limb among both genders.**

Gender	Male				Female			
	Eyes open		Eyes Closed		Eyes open		Eyes Closed	
SLST	pre	post	Pre	Post	pre	Post	pre	post
ONE	25	23	24	14	24	22	21	15
TWO	00	02	01	10	01	03	04	08
THREE	00	00	00	00	00	00	00	02

**Table 4: Number of attempts during Single Leg Stance Test (SLST) with eyes open and eyes close with Pre and post cold immersion on non-dominant side lower limb among both genders.**

Gender	Male				Female			
	Eyes open		Eyes Closed		Eyes open		Eyes Closed	
SLST	pre	post	Pre	Post	pre	Post	pre	post
ONE	24	22	13	04	24	22	14	02
TWO	01	02	12	19	01	03	11	21
THREE	00	01	00	02	00	00	00	02

From table 3 and 4 , it is observed that on both dominant and non dominant side lower limb, the number of attempts required to perform SLST were significantly more in post cold water immersion than pre immersion values in both genders. The number of attempt increases significantly more with eyes close condition compared to eyes open in both genders. It is also found that females were more affected with balance with SLST compared to males in both eyes open as well as eyes close condition. Hence it can be stated that balance affected more in females than males after cold water immersion among both

genders and with eyes close number of attempts to complete SLST increases.

## DISCUSSION

In the present study it was found that there is significant decrease in foot and ankle muscle strength as well as static standing balance in both genders immediately after cold water immersion in age group of 18 -25 years. In previous study (in 1993) Mattacola CG and Perrin DH [4] evaluated effect of cold water application on isokinetic strength of the plantar flexors and found there was decrease in the isokinetic strength of plantar flexor, which is in support with the present study. The study

(2015) by Bhoir T [1] on the application of cold temperature on hands found there was a significant decrease in hand grip strength. Douglas M [26] found that cryotherapy has a negative effect at ankle on the medial/lateral component of static and dynamic balance following ice water immersion. Fullam K et al (2015) [28] also found that cryotherapy adversely affects dynamic postural stability. Whereas (2015) Tano SS et al [29] found that there is an increase in muscle strength after 20 and 40 minute after cold water immersion, which contradict the findings of present study. In a study done by Alghadir HA (2017) [5] found no immediate effect of cooling for 20 minutes on thigh muscles i.e. quadriceps and hamstring muscles on standing balance in healthy individuals.

According to physiological changes after cold immersion due to cold there is decrease muscle temperature, slowing of nerve conduction velocity [4,12] causes vasoconstriction of blood vessels, reduces tissue metabolism, oxygen utilization and insufficiency of musculotendinous unit. [4] This can be observed that many studies [1,4,26] including results of present study found that cold reduces ankle muscle strength as well as static standing balance (single leg stance test with eyes open and eyes closed) immediately after cryotherapy in young healthy participants.

In current study, it was found that participants showed poor standing balance with eyes closed condition during single leg stance test compared to eyes open condition. It was found that proper balance is controlled by vestibular, somatic and visual senses. [12] Any alteration to these systems may affect balance hence with closed eyes participants showed poor balance in standing in both genders.

## CONCLUSION

Cold water immersion decrease foot and ankle muscles strength as well as standing balance, immediately with eyes open and eyes closed in both genders. Further study needed to evaluate long term effect of cold water immersion on larger

sample size for lower limb muscle strength and standing balance.

## REFERENCES

1. Bhoir T, Dr. Deepak B, Dr. Ashish J. Effect of hot & cold temperature on hand grip strength in normal individuals; Cross sectional study VIMS health Sci J. 2015 march; 2(1)13-15.
2. Bleakley C, McDonough S, MacAuley D. The use of ice in the treatment of acute soft injury. Am J Sports Med 2004; 32:251-61.
3. Mariusz Pawel Furmanek, Kajetan Slomka and Grzegorz juras: The effects of cryotherapy on proprioception system. Bio Med Research International 2014;14.
4. Mattacola, C.G.&Perrin,D.H. Effect of cold water application on isokinetic strength of the plantar flexors. Isokinetics and Exercise science,3, 152-159.
5. A.H. Alghadir, S.Anwer, H.Zafar, E.S.Al-Eisa. Effect of quadriceps and hamstring cooling on standing balance in healthy young men. J Msk Neuronal Interact. 2017 Sep;17(3):176-182.
6. G.E. White and G.D. Wells, "Cold-water immersion and other forms of cryotherapy: Physiological changes potentially affecting recovery from high-intensity exercise," Extreme physiology and medicine. Extrem Physiol Med.2013 Sep;2(1):26.
7. SF Nadler, K Weingand, RJ Kruse. The physiological basis and clinical application of cryotherapy and thermotherapy for the pain practitioner. Pain Physician. 2004. Jul;7(3):395-9.
8. Merrick MA et al. A preliminary examination of cryotherapy and secondary injury in skeletal muscle. Med Sci Sports Exerc 1999; 31:1516-1521.
9. Montgomery RE, Hartley GL, Tyler C J, Cheung SS. Effect of segmental, localized lower limb cooling on dynamic balance. Med Sci Sports Exec. 2015 Jan;47(1):66-7
10. Zankle H: Effect of physical agents on motor conduction velocity of the ulnar nerve. Arch Med Rehab 1996;12:787-792.
11. Krzysztof Zimmer" Considerable experience in the treatment of trauma sports medicine contributes to increasingly important development of general cryotherapy, and to the recognition of this method's effectiveness. Sports Med and Rehab 2003; 461-462.

12. Elley R. The effect of ice pack application at the ankle joint on one-legged balance ability. *J of Phys.* 1994; 17-22.
  13. Prentice W. Therapeutic modalities in sports medicine, 2<sup>nd</sup> ed, St. Louis: Times Mirror/Mosby, 1990.
  14. WS Barnes, MR Larsen. Effects of localized hyper and hypothermia on maximal isometric grip strength. *Am J Phys Med.* 1985; 64:305-314.
  15. Andrea A, Eduardo P, Stefano R. Validation of Ankle Strength Measurements by means of Hand -Held Dynamometer in Adult Healthy Subjects. *J of Sensors.* 2017; 8 <http://doi.org/10.1155/2017/5426031>
  16. M.J. Spink, M.R. Fotoohabadi, E. Week. D. Hill, S.R. Lord and H.B. Menze, foot and ankle strength, range of motion, posture and deformity are associated with balance and functional ability in older adults. *Archives of Phys Med and Rehab.* 2011; 92: 68-75.
  17. M. Galli, C. Rigoldi, R. Burner, "Joint stiffness and gait pattern evaluation in children with Down syndrome. *Gait Posture.* 2008 Oct; 28(3):502-6.
  18. WK. Kim, DK. Kim, KM. Seo and SH. Kang. Reliability and validity of isometric knee extensor strength test with hand held dynamometer depending on the fixation. *Ann Rehabil Med.* 2014 Feb; 38(1):84-93.
  19. DE. Tsaopoulos, V. Baltzopoulos, PJ. Richards, and CN. Maganaris, Mechanical correction of dynamometer moments for the effect of segment motion during isometric knee-extension tests. *J Appl Physiol* 2011 Jul; 111(1):68-74.
  20. Matthew Carroll, William Joyce. Assessment of foot and ankle muscle strength using HHD in patient with established rheumatoid arthritis. *J Foot Ankle Res.* 2013; 6:10.
  21. Stark T, et al, Hand held dynamometer correlation with the gold standard. isokinetic dynamometer: a systematic review. *PM R.* 2011 May; 3(5):472-9.
  22. Bohannon RW. Test-retest reliability of hand-held dynamometry during a single session of strength assessment. *Phys Ther.* 1986 Feb; 66(2):206-9.
  23. Kernozek TW, Greany JF, Anderson DR, et al. The effect of immersion cryotherapy on medial-lateral postural sway variability in individuals with a lateral ankle sprain. *2018 Jun; 13(2):107-18.*
  24. Kernozek TW, Greany JF, Anderson DR, et al. The effect of immersion cryotherapy on medial-lateral postural sway variability in individuals with a lateral ankle sprain. *Phys Ther Res Int.* 2018 Jun; 13(2):107-18.
  25. Miniello S, Dover G, Powers M, Tillman M, Wikstrom E. Lower leg cold immersion does not impair dynamic stability in healthy women. *J of Sports Rehab.* 2005; 14(3): 235-247.
  26. Matthew Douglas et al. Immediate effects of cryotherapy on static and dynamic balance. *International. J of Sports Phys Ther.* 2013 Feb; 8(1): 9-14.
  27. Cynthia C, Norkin D, Joyce White. Measurement of Joint Motion. 4 :263-289.
  28. Karl F, Brian C, Garrett FC, Mark Mc, and Eamonn D. Dynamic Postural- Stability Deficits After Cryotherapy the Ankle Joint. *J of Athletic Training.* 2015 Sept; 50(90): 893-904.
  29. Tano SS et al. Effects of cold water immersion on variables of balance in healthy subjects with open and closed eyes. *Fisioterapia em mov.* 2015 Sept; 28:3.
- How to cite this article: Deshmukh AA, Lilariya D. Immediate effect of cold water immersion on foot and ankle muscle strength and standing balance in young healthy individuals: a clinical trial. *International Journal of Science & Healthcare Research.* 2019; 4(3): 179-184.

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