IMMERSION OF LOWER BODY PARTS WITH COLD WATER REDUCES PHYSIOLOGICAL RESPONSES AND ENHANCES DISTANCE COVERED RUNNING IN HOT ENVIRONMENT

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Abstract

The purpose of the present study was to examined the effects of a 12-min cold water immersion(CWI) on each of, core temperature (Tc), oral temperature (To), heart rate (HR) and running distance covered performance in the second trial in a hot environment. Ten participant (mean age 30.5±5.54 years ; height 1.84.1±5.10 ; body mass 76.62± 9.48 kg,) completed two testing sessions separated by one week; each trial consisted two bouts of a 30-min running on hot condition (30.90°±1.28°C, 72.6±5.68% relative humidity). The two bouts were separated by either 22 min of seated recovery in the heat (non-CWI) or the same condition with 12-min CWI(mean 15±1°C (5th–17th minute). HR, Tc, To and distance in second bout were recorded throughout the testing sessions. There was a significant incline in performance-trial from Test1 to Test2 using CWI (7010 ± 495.92 m) compared to the change seen non-CWI (6887± 490.42). (Tc) was reduced following non-CWI (37.94 ±1.0ºC) compared with CWI (37.52 ± 0.4 ºC). The total HR during the non-CWI and CWI test was (96.50 ± 14.27pbm) (decline range 84.7 pbm) and (84 ± 9.84 pbm) (decline range 93.5pbm), respectively. (To) no deferent between non-CWI recovery (36.50±.318ºC) ,compared to the change seen CWI (36.50±.405ºC). 12-min cold-water immersion recovery significantly lowered (Tc) and maintained endurance performance during second test session . These data indicate that repeated exercise performance in heat may be improved when a short period of cold-water immersion is applied during the recovery period.

Keywords Cold water immersion. Core temperature. Recovery .

1. INTRODUCTION

The high temperature is one of the most challenging factors that is long-distance runners (endurance sport) are suffering from (Lawrence et al. 1996; Susan. 2005; Darren and Scott. 2006). Thus, running for long distances in a hot weather causes an increment in coetaneous blood flow to get rid of the excessive temperature which is a result of metabolic heat production and the increment of the local temperature. so that the runner could have thermal fatigue, and straining cardiovascular as well, because of the breathing in the blood amount among skin and working muscles including brain, which leads finally to the fatigue.

The Thermal strain happens when the rate of metabolic heat production is higher than the ability of the body's ability to get rid of it (Lawrence et al. 1996; Susan. 2006). The increment of this production while the runner is running in a hot weather which ends up with thermal pressure (Herbert and Terry. 1994; Bodil and Lars.2003; Darren and Scott.2006). From another point of view, under the same conditions or because of dryness, (Nag et al.1998; susan.2005), Arterial hypotension, Low cardiac output, High pulse rate, Increment pulmonary ventilation and low cerebral blood flow (Marino. 2002; Cariget al.2003; Marc et al.2006).

Loosing 2% of the mass body because of sweating might happen because of the running for 60 minutes or more in a hot weather (above 30°C), while the player may reach to that percentage when he runs for 90 minutes or more in a cold weather (5-10 C°), average temperature (18-22 °C) or warm weather (24-29 °C), (susan.2005), so that this affects the volume of the body fluid inside and outside the cells as well (Maw et al.1998; Stocks et al.2004). On the other hand, the thermal makes the brain activities to be changed, since it is one of the most affected-organs with the thermal strain, (Duffield et al., 2003) and causes failure of the motor cortex which is resembled in decreasing motivation/willful activation of the muscle, so that it is one of the most causes for happening central fatigue (Marino.2002; Bodil and Lars.2003; gabrielle et al.2005; Susan.2005; Marc et al.2005).

The player who is suffering from **thermal strain** and mental status changes in the long-distance running in a hot weather, the immediate rapid cooling by immersing in cold water, and this way is good and it is advised until the anus temperature decreases to(38C°),(Lawrence et al. 1996; Eranet al.2004; James et al.2005; Darren and Scott.2006), so immersion in the cold water increases blood pressure, to the natural rate, by peripheral vasoconstriction /increasing its resistance (Stocks et al. 2004), which causes the impulse of the cold-blood to the core and cooling it.) On else more, it lessens inflammation of the infected tissues and the hematoma as well (Bailey et al.2007). Therefore, a strategy to reduce core temperature during halftime breaks (15 min) could minimize the reduction in performance that is often observed during the second half. The effectiveness of cold water immersion for decreasing core temperature and increasing the heat storage capacity of individuals during exercise has been quantified.

For example, after 30 min of 14°C torso-only cold water immersion, Marsh and Sleivert .,1999 reported an average decrease in rectal temperature of 0.3°C during a15-min exercise session. Additionally, Kay et all.,1999 observed a significant increase (158 2 30 min of constant-paced cycling following 58 min of 25°C whole-body cold-water immersion, when compared with a control condition.

Despite the promise of using cold-water immersion recovery to improve exercise performance in the heat, controversy exists concerning its effectiveness. For example, Crowe et al.,2007 and Schniepp et al.,2002 reported a decrease in cycling sprint performance after a 15-min whole-body cold-water immersion (14°C) intervention.

However, both of these studies were conducted in non-hyperthermia conditions (≤ 27°C), which do not represent a practical scenario for applying a cold-water immersion intervention. Conversely, Yeargin et al.,2006 showed that 12 min of whole-body cold-water immersion (14°C) after 90 min of running in the heat significantly reduced the time to complete a 2-mile running time trial compared with a control condition.

Also, from the literature review of physical performance in hot environments, I found that previous studies that used the cooling process of the body (either upper body or lower body) were conducted in laboratory. Traditionally, each of forehead, temporal, oral, aural, and axillary oral body sites have been used for body temperature measurement although these methods are not accurate when measuring a real intestinal body temperature during the physical activity. However, it has been suggested by Matthew at et al.,2009 that measuring intestinal temperature is necessary for evaluating a real body temperature.

It seems that using vital sense is one of the most appropriate methods for measuring intestinal body temperature. Importantly, because laboratories do not reflect real conditions of sport competitions, in the present study was conducted in the external environment. The study aim was to investigate the effect of lower body immersion in cold water during the rest period between two sets of 30 min tests, in the hot environment, on the running distance covered, and some of the physiological responses.

2. METHODS

Participant

The study received prior approval from the Marmara University ethics committee, and athlete provided written informed consent to participate after reading a document describing the nature, benefits and possible risks of the study. Ten well-trained male athletes (age: 30.5±5.54 years, height: 184.1± 5.10 cm, weight:76.62± 9.48 kg, Vo2max: 54.1 ± 7.2 ml /kg/min) agreed to participate this study. All participant had been training for at least 5 years and had a weekly training volume that was greater than 5days in a week .

The subjects were required to complete one shuttle run test, and two experimental sessions separated by 4–7 days. The average temperature and humidity of Istanbul were 30.90±1.28C, 72.6±5.68% in august(http://www.meteor.gov.tr). The athletes were not heat acclimated before the first test and they did not perform any intense training in the few days before or between the test.

Shuttle Run Test

Before the experimental trials, maximum oxygen uptake (VO2max) was determined from a progressive intensity and continuous effort shuttle run protocol. The test consisted of continuous running back and forth between two lines 20 meters apart from each other within a given time. The time was shortened every 2 minutes, which therefore increased the running speed. Players had to run until their volitional limit at which they were not able to keep up with the running speed. Additionally, the validity of the test was shown to be high as well (r = 0.92), showing a high correlation between performance in the multistage 20m shuttle run test/beep test and a "true" VO2max measurement with a spirometry (Alemdaroglu,U.et al.2012. Aziz, A. R., H. Y. Frankie and C. T. Kong.2005. Flouris, A. D., G. S. Metsios and Y. Koutedakis.2005)

Core temperature measurement

Core temperature (Tc) was monitored using a Vital Sense telemetric physiological monitoring system (Mini Mitter Co. Inc., Bend, Oregon, USA), which consists of a receiver and a thermistor-based, ingestible jonah core temperature sensor capsule. as reviewed extensively by byrne and lim (2007), the ingestible telemetric temperature sensor represents a valid index of core temperature measurements. The validity of self-calibrated sensors and core body temperature monitoring systems had been shown by McKenzie and Osgood (2004). sensors were activated approximately 5 h before the test and swallowed immediately after activation. By the time of the test session , the sensors would have passed through the stomach and the temperature measurements would not be substantially affected by the ingestion of hot or cold liquids. All the swallowed thermo sensor pills were checked before the test to ensure the device residing in the athletes was transmitting a signal. Signals from the sensor were collected just before the test to record initial core temperature values.

HR Measurement

HR was monitored continuously using a wireless HR monitor (RS800, RS400 Polar, Finland).

Oral Temperature Measurement

Oral temperature (To) was monitored using a (microlith digital clinical Thermo - REF MT 3001) before and after each round of running.

Cold water immersion

During the 12-min cold-water immersion, subjects were submerged in an inflatable water bath, in a seated position to the iliac crest level, wearing only their cycling shorts. Water temperature was maintained at a constant 15±1°C. The water temperature selected for this study (15±1°C) was chosen as it appears as the most commonly used water temperature in previous cold-water immersion studies (lane et all., 2004.yeargin et all., 2006.clements et all., 2002. Mitchell et all., 2002) and is effective at lowering body temperature and is tolerable for most subjects.

Experimental sessions

All athlete swallowed the activated thermo sensor about 5 hour before the test. Approximately 30 min before the start of the test, The physiological and anthropometric variables was measured, wearing only underwear, were weighed to the nearest 50gr using a digital scale. Before and after the two trial one investigator from the research team recorded round, HR and body core temperature. During the two experimental sessions, participant completed 30 min of running in the track that corresponded to 80-85% of Vo2max in an environmental chamber maintained at 30.90 ±1.28°C and 72.6±5.68% relative humidity. The intensity and duration of the constant-pace session were selected to provide an adequate stimulus to increase core temperature . Participant were permitted to warm-up before first session for 20 minute.

After the first time trial, the CWI group were submerged (to the iliac crest) in an inflatable ice bath for a period of 12 min wearing short trousers. The temperature of the water was maintained at 15 ±1°C by adding crushed ice. To isolate the recovery benefits of cold-water immersion, passive sitting occurred before and after the cold-water immersion period. During the control condition, participant were seated for the entire 12 min in the 25±1°C heat chamber. After the 12-min recovery period, we measured the physiological changes from the participant, then repeat the running a second 30 minutes of running in the track that corresponded to 80-85% of Vo2max. After the second trial We have once again to measure variables, compare them with the control group (non-CWI). And two experimental sessions separated by 4–7 days.

Statistical analysis

Values are reported as mean -standard deviation. Statistical significance was accepted as P≤0.05 with a confidence interval of 95%. Pre and post-match variations within the experiment were evaluated with Wilcoxon signed ranks test.

3. RESULTS

Meteorological measurements

The average ambient temperature for the august test was 30.90± 1.28 °C with a relative humidity of 72.6± 5.68%. The CWI and non-CWI test were take place between 12:00 and 14:00 clock. The average temperature and humidity were taken from the website written down. (http://www.meteor.gov.tr).

Performance

There was a significant incline in performance-trial in Test2 more than Test1 by using cold water immersion (CWI) test (7010 ± 495.92 m) compared to the change seen non cold water immersion (non-CWI)test (6887± 490.94) (Fig 1). The total distance covered during the control and CWI test was (6698 ± 625.94m) (range 5600-8000 m) and 6948.5 ± 492.5m (range 6400 –8000 m), respectively. The total distance covered in the first and second halves was 6902 ± 494.00 and 6494 ±757.89m for the control test (non- immersion) and 6887 ± 490.94 and 7010± 495.42 m for the CWI test , respectively.

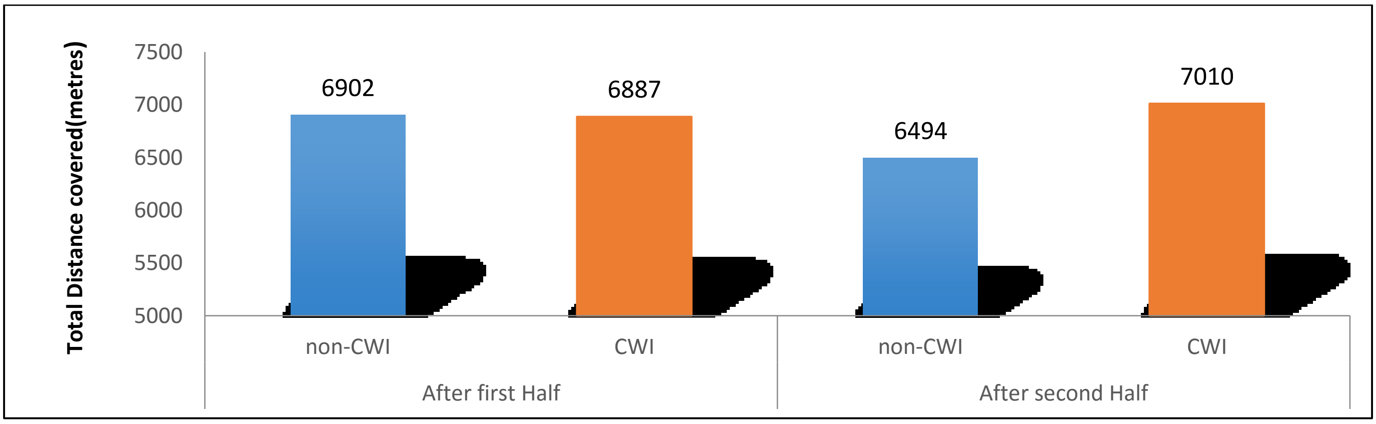

Fig. 1. Total distances covered in first and second test of non-CWI and CWI test. *The significant difference between second halves of CWI test (P≤0.005)

There was no difference in distance covered between the two halves of the non-CWI test, however athlete covered less distance in the second half about 408m of the non-CWI test than they did in the first half (Fig. 1). In the CWI Test, There was no difference in the covered distance between the two halves; athletes covered more distance\average in the second half about 123 m than they did in the first half (Fig. 1) and table(1).

For the CWI it has been noticed that the average covered distance was 516m more than that of the non-CWI

Table (1).Wilcoxon rank test result to clarification statistical differences in total distance covered between first and second test for non-CWI and CWI trial.

Total distance covered	Rank	N	Mean of rank	Sum of rank	z	Sig*
After first and second Half (Non-CWI)	Negative rank	**7**	**5.07**	**35.50**	1.541	.123
	positive rank	**2**	**4.75**	**9.50**		
	Tie	**1**				
	Total	**10**				
After first and second Half (CWI)	Negative rank	**1**	**5.50**	**5.50**	1.466	.143
	positive rank	**6**	**3.75**	**22.50**		
	Tie	**3**				
	Total	**10**				
after first half Non-CWI vs. CWI	Negative rank	**3**	**2.50**	**7.50**	0.921	.357
	positive rank	**1**	**2.50**	**2.50**		
	Tie	**6**				
	Total	**10**				
After second half Non-CWI vs. CWI	Negative rank	**1**	**3.50**	**3.50**	2.261	.024*
	positive rank	**8**	**5.19**	**41.50**		
	Tie	**1**				
	Total	**10**				

p <0,05*

Core temperature measurements

Athletes began the two test with similar body core temperatures as measured after their warm up had been completed(36.87±.380°C) and (36.57±.327°C) for non-CWI and CWI test, respectively. However, there no difference between test in core temperature values in the first half. After first half, core temperatures increase to 39.07± .407° C for non-CWI, and 39.19 ±.432 °C for CWI test was measured, the results showed statistically no significant (P<0.05) differences for non-CWI and CWI, respectively. The CWI group were submerged (to the iliac crest) in an inflatable ice bath for a period of 12 min wearing short trousers. The temperature of the water was maintained at 15 ±1°C by adding crushed ice.

Mean of recovery level after submerged and before start the second trial for core temperatures, in non-CWI test was decrease from 39.07 to37.94 C, (decline range 1.13 °C) . In the CWI test ,mean of recovery level for core temperatures was decrease from 39.19 to 37.52 °C (decline range 1.67 °C). There were statistically significant p <0,05 differences between the two trials after immersion and before second trial.

After the second trial the total core temperatures in the control (non-CWI)test increase from 37.94 to 39.27°C(incline range 1.33°C), in the CWI test increase from 37.52 to 38.56 °C (incline range 1.04 °C) there were statistically significant p <0,05 differences between the two trials after second half (fig.1).

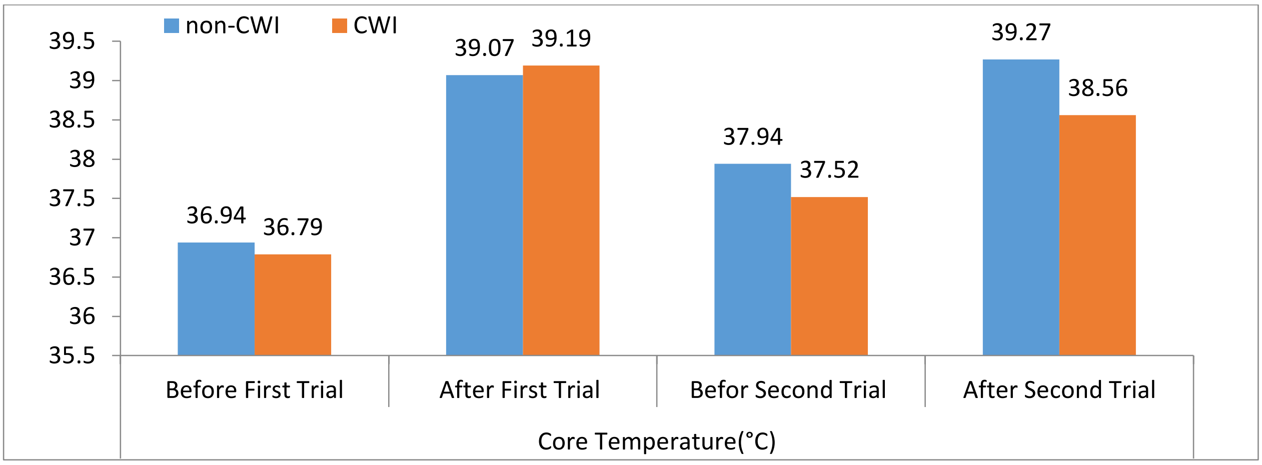

Fig. 2. Core temperature (Tc) before and after first trial and second trial of non-CWI and CWI test. *The significant difference between first and second halves of CWI test (P≤0.005).

Table (2).Wilcoxon rank test result to clarification statistical differences (Tc) between first and second test for non-CWI and CWI trial.

Core temperature (Tc)	Rank	N	Mean of rank	Sum of rank	z	Sig*
Before first Half (Non-CWI vs. CWI)	Negative rank	8	5.00	40.00	1.274	0.203
	Positive rank	2	7.50	15.00		
	Tie	0				
	Total	10				
After first half (Non-CWI vs. CWI)	Negative rank	3	6.83	20.50	.714	0.475
	Positive rank	7	4.93	34.50		
	Tie	0				
	Total	10				
Before second half (Non-CWI vs. CWI)	Negative rank	10	5.50	55.00	2.803	0.005*
	Positive rank	0	.00	.00		
	Tie	0				
	Total	10				
After second half (Non-CWI vs. CWI)	Negative rank	10	5.50	55.00	2.803	0.005*
	Positive rank	0	.00	.00		
	Tie	0				
	Total	10				
Deferens between before and after second half of (Non-CWI vs. CWI)	Negative rank	**8**	**5.25**	**42.00**	1.478	.139
	positive rank	**2**	**6.50**	**13.00**		
	Tie	**0**				
	Total	**10**				

p <0,05*

Oral Temperature

Athlete began the two test with similar body oral temperatures as measured after their warm up had been completed (36.53±.266°C) and (36.59±.264°C) for non-CWI and CWI test, respectively. After first half, oral temperatures increase to 39.23 for non-CWI, and 39.29 for CWI test was measured, the results showed statistically no significant (P<0.05) differences for non-

CWI and CWI, respectively. The CWI group were submerged (to the iliac crest) in an inflatable ice bath for a period of 12 min wearing short trousers. The temperature of the water was maintained at 15 ±1°C by adding crushed ice.

Mean of recovery level after submerged and before start the second trial for core temperatures, in non-CWI test was decrease from 39.23 to 36.50°C, (decline range 2.73 °C) . In the CWI test ,mean of recovery level for core temperatures was decrease from 39.29 °C to 36.50 °C (decline range 2.79°C). there were statistically significant p <0,05 no differences between the two trials after immersion and before second trial.

In both test, oral temperatures fell during the half-time break, and did return to the peak first half level during the second half of the match .

The total oral temperatures after second half, in the non-CWI test increase from 36.5 to 38.96°C (decline range 2.46°C), and CWI test increase from 36.5 to 38.74 (decline range 2.24° C) there were statistically significant p <0,05 no differences between the two trials after second half (fig.3).

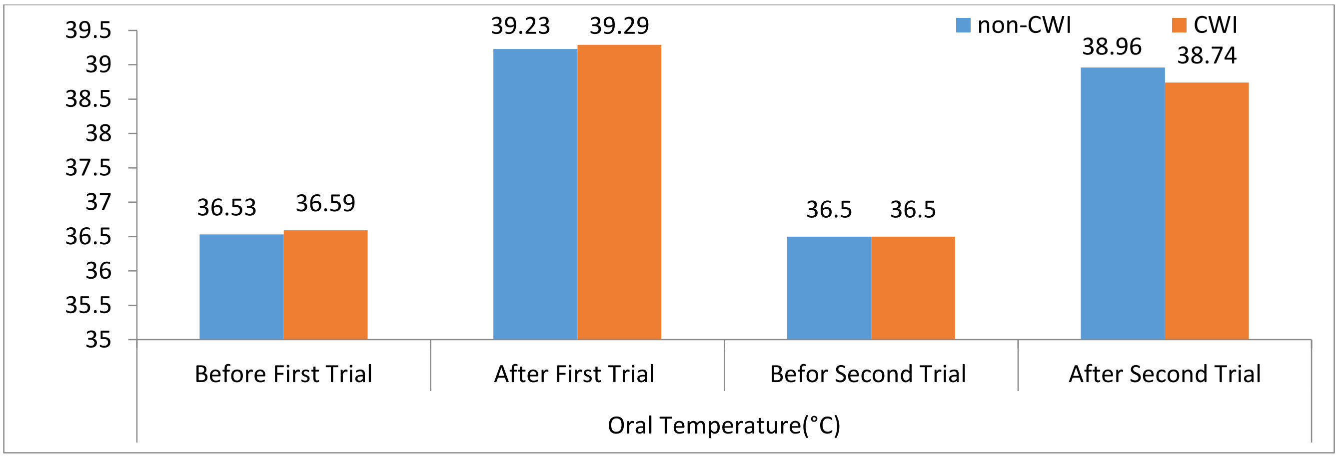

Fig. 3. Oral temperature (To) before and after first trial and second trial of non-CWI and CWI test. *The significant difference between first and second halves of CWI test (P≤0.005).

Table (3).Wilcoxon rank test result to clarification statistical differences (To) between first and second test for non-CWI and CWI trial.

Oral Temperature (To)	Rank	N	lean of rank	um of rank	z	Sig*
Before first Half Non-CWI vs. CWI	Negative rank	6	3.67	22.00	0.059	.953
	Positive rank	3	7.67	23.00		
	Tie	1				
	Total	10				
After first half Non-CWI vs. CWI	Negative rank	2	8.50	17.00	1.071	.284
	Positive rank	8	4.75	38.00		
	Tie	0				
	Total	10				
Before second half Non-CWI vs. CWI	Negative rank	5	6.30	31.50	.409	.683
	Positive rank	5	4.70	23.50		
	Tie	0				
	Total	10				
After second half Non-CWI vs. CWI	Negative rank	6	3.67	22.00	1.479	.139
	Positive rank	3	7.67	23.00		
	Tie	1				
	Total	10				

eferens between Before and after second half of (Non-CWI vs. CWI)	Negative rank	7	5.29	37.00	.968	.333
	positive rank	3	6.00	18.00		
	Tie	0				
	Total	10				

p <0,05*

Heart Rate (HR)

Average HR in the first half of the non- CWI test was higher in both halves (181.2 ± 10.99 pbm), In the CWI test ,athlete mean HR in the first half was (177.50 ± 11.20 bpm), in the second half (177.60±11.14 bpm). The results showed statistically no significant(P<0.05) differences between test in first half. The CWI group were submerged (to the iliac crest) in an inflatable ice bath for a period of 12 min wearing short trousers. The temperature of the water was maintained at 15 ±1°C by adding crushed ice. Mean of recovery level after submerged and before start the second trial for core temperatures, in non-CWI test was decrease from 181.2 pbm to 96.50 pbm , (decline range 84.7 pbm) . In the CWI test ,mean of recovery level for core temperatures was decrease from 177.5pbm to 84 pbm (decline range 93.5pbm). there were statistically significant p <0,05 differences between the two trials after immersion and before second trial. In both test, heart rate fell during the half-time break, and did return to the peak first half level during the second half of the test. There were no statistically significant p <0,05 differences between the two trials in the first and second half. After the second half the total HR in the non-CWI test increase from 96.5 pbm to 180.3 pbm (decline range 83.8 pbm), and CWI test increase from 84 pbm to 177.6 pbm (decline range 93.6 pbm) there were statistically significant p <0,05 no differences between the two trials after second half.

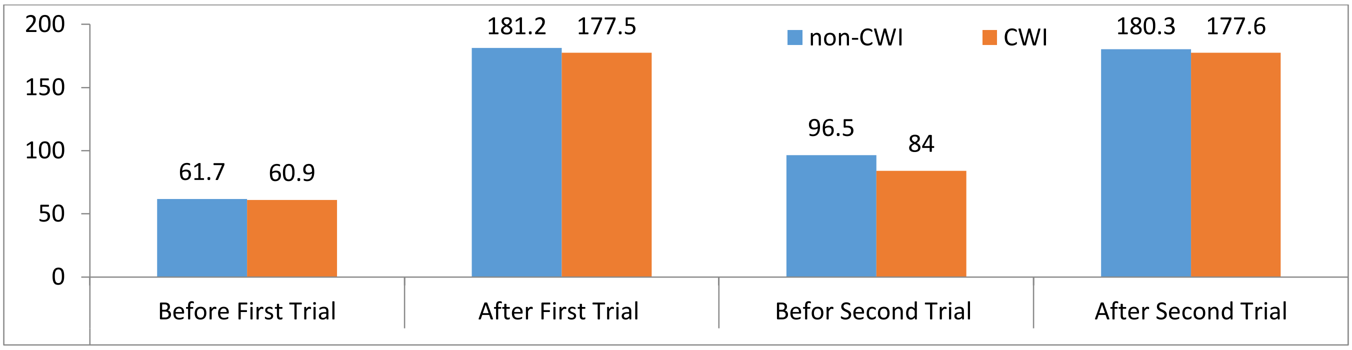

Fig. 4. HR before and after first trial and second trial of non-CWI and CWI test. *The significant difference between first and second halves of CWI test (P≤0.005).

Table (4).Wilcoxon rank test result to clarification statistical differences (HR) between first and second test for non-CWI and CWI trial.

HR(Pbm)	Rank	N	Mean of rank	Sum of rank	z	Sig*
Before first Half Non-CWI vs. CWI	Negative rank	3	4.67	14.00	.000	1.000
	Positive rank	4	3.50	14.00		
	Tie	3				
	Total	10				
After first half Non-CWI vs. CWI	Negative rank	5	5.10	25.50	1.051	.293
	Positive rank	3	3.50	10.50		
	Tie	2				
	Total	10				
Before second half Non-CWI vs. CWI	Negative rank	10	5.50	55.00	2.809	.005*
	Positive rank	0	.00	.00		
	Tie	0				
	Total	10				

After second half Non-CWI vs. CWI	Negative rank	6	5.08	30.50	.949	.342
	Positive rank	3	4.83	14.50		
	Tie	1				
	Total	10				
Deferens between Before and after second half of (Non-CWI vs. CWI)	Negative rank	1	1.00	1.00	2.549	.011*
	Positive rank	8	5.50	44.00		
	Tie	1				
	Total	10				

p <0,05*

4. DISCUSSION

Performance

Athletes covered more distance\average in the second half about 123 m than they did in the first half of the cold water immersion(CWI) test (Fig. 6). For the CWI it has been noticed that the covered distance was 516 m more than that of the non-CWI. From the above mentioned result it can be inferred that Using cold-water immersion recovery to improve exercise performance in the heat. And in our data indicate that 12 min of cold-water immersion during a 22-min recovery session can decrease core temperature and attenuate the decline in high-intensity exercise performance without affecting submaximal economy of motion in hot environmental conditions. And it concerts with the study of Wilcock et al., 2006. cooling techniques in hot conditions aim to rapidly reduce elevated thermoregulatory and cardiovascular strain, alleviating impaired neuromuscular function and facilitating the maintenance of subsequent exercise performance.

Core temperatures (Tc)

The effectiveness of cold water immersion for decreasing core temperature and increasing the heat storage capacity of individuals during exercise has been quantified (Kay D, Taaffe DR, Marino FE .1999) For example, after 30 min of 14°C torso-only cold water immersion, Marsh and Sleiver.,1999, reported an average decrease in rectal temperature of 0.3°C during a 15-min exercise session. Additionally, Kay et al.,1999, observed a significant increase (158(13.1W m2) vs. 84 (8.8 W m)) in heat storage capacity during 30 min of constant-paced cycling following 58 min of 25°C whole-body cold-water immersion, when compared with a control condition.

In the present study, core temperature increased rapidly from first half on both test, and the rate of increase was not apparently different between non-CWI and CWI during the first test . In the second half of the test there was little increase in core temperature in the non-CWI test, furthermore it continued to rise in the CWI test so that mean core temperature was about 0.3°C in the more high heat environment. Even though the Running distance which average covered by the athletes in the CWI test is more than they covered in the non-CWI test, the degree of core body temperature was lower in CWI test.

Oral Temperatures(To)

Evidence suggests that, regardless of whether the assessment is recorded at rest or during periods of changing core temperature, oral temperature is an unsuitable diagnostic tool for determining body temperature because many measures demonstrated differences greater than the predetermined validity threshold of 0.27°C (0.5°F). In addition, the differences were greatest at the highest core temperatures. Oral temperature cannot accurately reflect core body temperature, probably because it is influenced by factors such as ambient air temperature, probe placement, and ingestion of fluids. Any reliance on oral temperature in an emergency, such as exertional heat stroke, might grossly underestimate temperature and delay proper diagnosis and treatment. (Mazerolle et al.,2010.2011). And in our data indicate that because there was no deference's between non-CWI and CWI test. On the other hand the result show differences between CWI test and non-CWI test by using ingestible capsule to measure the internal temperature.

Heart Rate (HR)

If we see the level of increase for each of the first and the second half for both non-immersion and immersion were as follows:

Non- immersion : It rose in the first half from 120 to 189 pbm, at the rate of increase up to 69 pbm, and in the second half it rose from 122 to190C at the rate of increase up to 68pbm. **In cold water Immersion test :** It rose in the first half from 115 to 190 pbm, at the rate of increase up to 75 pbm , and in the second half it rose from 113to 175 pbm, at the rate of increase up to 62pbm. This shows that the immersion in cold water test contributed to the improved performance more than non-immersion test. As a result, it showed a decrease in the heart rate ,which is reflected in the running for a more distance in the second half. This can be explained that the longer distance running in the second half rather than first half of the test. The reduction in HR following CWI may also be the consequence of a more rapid rise in parasympathetic activity that may or may not be independent of blood redistribution. During the final stages of test 2, during the all-out performance-trial phase, there was no difference in heart rate, although significantly more work was completed during the performance-trial following CWI compared with non- CWI.

5. CONCLUSION

1- 12-min cold-water immersion recovery significantly lowered core temperature with a decrease in total distance covered in the second half of the test, compared to non-CWI.
2- This information is pertinent to athletes, if they do have immediate access to recovery facilities between exercise performance.
3- In present study ,Oral body sites have been used for body temperature measurement although these methods are not accurate when measuring a real intestinal body temperature during the physical activity. However, it has been suggested by Matthew at et al. (2009) that measuring intestinal temperature is necessary for evaluating a real body temperature.

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