CHALLENGING PARADIGMS: WHY WARM UP PRIOR TO EXERCISE?

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ABSTRACT

There appears to be a common consensus within the exercise and sporting fraternity that prior to physical activity an individual should 'warm up' in order to lessen the risk of injury and optimise his or her performance. In this context, there is an alternative viewpoint that indicates that a 'warm up' may, in certain conditions, be counter productive, and that cooling down an individual prior to exercise may elicit better performance outcomes.

A study into the warm-up phenomenon was undertaken to examine the effect of lower body pre-cooling on the duration of high intensity running performance when compared to a 'normal' or non pre-cooled protocol, and to evaluate individual responses in terms of Running Distance Achieved, Core temperature, Heart rate response and Ratings of Perceived Exertion. Three test protocols were performed by the participants based on the 20 m Multi-Stage-Fitness Test (20MSFT) (Leger et al., 1988). Test one involved the standard 20MSFT protocol to predict aerobic performance, while Test 2 and 3 required a participant to start from the end shuttle obtained in the first aerobic test. Randomised selection of Test 2 or 3 involved either pre-cooling, or a 'normal' warm up scenario. Eight participants with a mean age of 18.6 years volunteered for the research with written informed consent. The study showed a significant increase in the number of shuttles completed in the pre-cooled state as opposed to normal state. The results of this study challenge the widely accepted 'warm up' paradigm, and demonstrate that pre-cooling intervention (opposed to a warm up) increased the duration of high intensity running performance by 11.56%.

INTRODUCTION

Endurance Training is known to produce adaptive thermoregulatory modifications such as enhanced sweating sensitivity (Gissolfi & Robinson, 1969: Henane et al., 1977: Nadel et al., 1974: Piwonka et al., 1965: Roberts et al., 1977: Senay & Kok, 1977: Shvartz et al., 1977), lowered threshold temperatures for sweating (Baum et al., 1976: Henane et al., 1977: Nadel et al., 1974: Roberts et al., 1977), forearm skin vasodilatation (Roberts et al., 1977), and shivering (Baum et al., 1976). These changes contribute to the lowered level of internal body temperature found in physically fit participants during exercise, upon heat exposure, during rest at neutral temperature as well as at cold exposure (Baum et al., 1976: Adams & Heberling, 1958).

The above modifications may be advantageous in that they counteract the danger of reaching a critically high exercise body temperature that is one of the factors limiting endurance performance (Adams et al., 1974: Pugh et al., 1967: Saltin et al., 1972), but this appears to contradict the widespread belief that exercise is improved by warm-up maneuvers and that low body temperatures are not compatible with maximum exercise performance. Accordingly, investigators (Hessemer et al., 1984: Kruk et al., 1990: Olschweski & Bruck, 1988) have reasoned that increased body temperature by warming up before vigorous exercise may not be beneficial, because warming up increases pre-exercise body temperature and subsequently narrows the range of body temperature within which thermal homeostasis is normally maintained. In addition, lowering body temperature provides a wider temperature span before upper critical body temperature can be reached (Nadel, 1987).

Pre-cooling might increase exercise endurance by lowering the starting body temperature and allowing more work to be completed before critical limiting temperature is reached (Schmidt & Bruck, 1981). In addition, pre-cooling allows a greater rate of heat storage with less strain on the metabolic and cardio-vascular functions during prolonged exercise (Lee & Haymes, 1995).

To elicit beneficial effects of body pre-cooling on exercise duration, the exercise mode has to produce adequate heat to overload the heat dissipation mechanisms of the body. Involvement of a greater muscle mass is essential to a high rate of heat production in a given time during exercise (Bergh & Ekblom, 1979: Olschweski & Bruck, 1988) In doing so, a pre-cooled body should store a larger amount of heat as well as delay the onset of heat dissipation mechanisms.

The purpose of this study was to examine the effect of lower body pre-cooling on the duration and distance of high intensity running performance utilising the 20MST (Leger et al., 1988) which provided a standardised test for all participants, allowing an accurate estimation of V02 Max, as well as providing an effective indication of high intensity running performance during the second and third phase protocols of testing. In addition, Core temperature, Heart rate response and Ratings of Perceived Exertion were measured.

METHOD

Participants

Eight 1st team level rugby players (either school level and/or U.20 representative level at Natal Provincial level, South Africa) volunteered to participate in this study. All participants had recently completed their 1st team fixtures and were considered to be above average in terms of both aerobic and anaerobic capacities. None of the participants reported any injury or health-related problems. Informed consent was obtained from all the participants prior to the testing. All the participants were familiar with the multi-stage shuttle run test (20MST) which was used, and they had all participated in the test at some stage prior to the study. All participants refrained from any vigorous exercise 24 hours prior to any of the tests. All three tests where performed at the same time of day in similar conditions within five days of each other, thus eliminating any training affect. The same researcher supervised all the testing.

Testing Procedures

The testing was completed on South African U.20 rugby players. Each subject was required to perform three tests, all using the multi-stage shuttle run test.

Test one involved the standard 20MSFT protocol to predict aerobic performance, while Tests 2 and 3 required a participant to start from the end shuttle obtained in the first aerobic test. Randomised selection of Tests 2 or 3 involved either pre-cooling, or a 'normal' warm up scenario. These tests were separated by a period of 5 days, ensuring the effects of fatigue were eliminated as well as any training affect, which may have developed.

20MST Protocol

Two lines were marked out on the level rugby playing field, 20 metres apart. The participants ran back and forth on the 20-meter straight course touching the 20-metre line with one foot at the moment that a sound signal was emitted from an audiotape. The frequency of the sound signal increased in such a way that the running speed increased by 0.5 km/hr each minute, from the initial running speed of 8.5 km/hr. When the participants could no longer maintain the prescribed pace, after receiving two warnings for not reaching the line at the time of the signal, the test was terminated on the third warning. The score was taken as the last shuttle where the subject's foot crossed the line prior to or at the same time as the signal.

Test One: Predicted VO_2 Max

The first test required the normal procedure of the multi-stage shuttle run, with the participants starting at level 1 and continuing until they could no longer maintain the prescribed pace.

Participants were to run the incremental test to volitional exhaustion to determine maximal aerobic power, VO_2 max, and thus maximum shuttle completed. Heart rate and rating of perceived exertion (RPE) was recorded at the completion of each stage and core temperature was recorded at the start and end of the multi stage fitness test. Heart rate was monitored by means of a Polar heart rate monitor (HR; Polar sports tester, Polar Electro, Finland) and RPE was monitored on the exertion scale of Borg (1970). Core temperature was measured through the external auditory canal so that it was close, but not touching the eardrum by means of the Braun Thermoscan.

High Intensity Running Test: Thermoneutral.

The second and third tests required that the participants started the Multi-Stage shuttle run at the level and stage that they achieved (or terminated their running at) in the first test. Thus the second test started from the end point of the previous test, and the participant was encouraged to run for as long as possible until they could no longer maintain the prescribed pace. This was a high intensity running test, designed to elicit an indication of anaerobic ability. The heart rate, RPE, and core temperature was recorded under the thermoneutral conditions.

High Intensity Running Tests: Pre-cooled

In the third test, like the second, participants continued trying to achieve the highest level possible, from the end point of the first test, before no longer being able to maintain the prescribed pace, however a key intervention was the pre-cooling maneuver. Heart rate, RPE, and core temperature were duly recorded.

Pre-cooling Manoeuver

The participants were required to recline in a large waste-paper bin filled with water and ice, to the level of the hips. The water temperature was set at 0 to −1ßDC. The water temperature was maintained through the continual addition of ice throughout the duration of the testing. The immersion protocol lasted for three minutes. All of the participants tested, were able to endure the three-minute immersion period. Once participants left the water bin they were towelled dry, and commenced the multi-stage fitness run (at the point they withdrew in Test 1) within 30–45 seconds of leaving the water.

Statistical Analysis

The results were analysed using descriptive statistics, and dependent t-tests, where significance was determined using a two-tailed probability of h0.05.

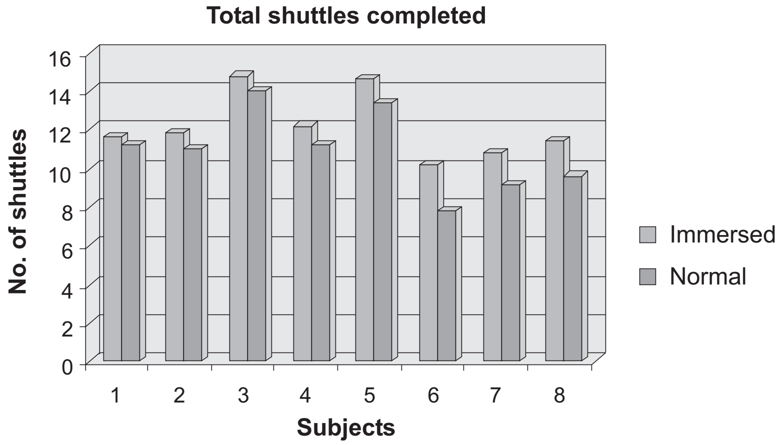
RESULTS

Termination Data

Running Performance

The results ($P < 0.05$) revealed that there was a significant increase in the number of shuttles completed between the normal and pre-cooled states. (See figure 1) There was an 11.56% increase in shuttles completed between the normal and pre-cooled runs.

Fig 1. Effect of pre-cooling on the number of shuttles completed.



Heart rate
There was no significant difference in heart rate at the completion of both the normal and pre-cooled tests (P<0.05).

Core Temperature
There was no significant difference in core temperature at the completion of both the normal and pre-cooled tests (P > 0.05).

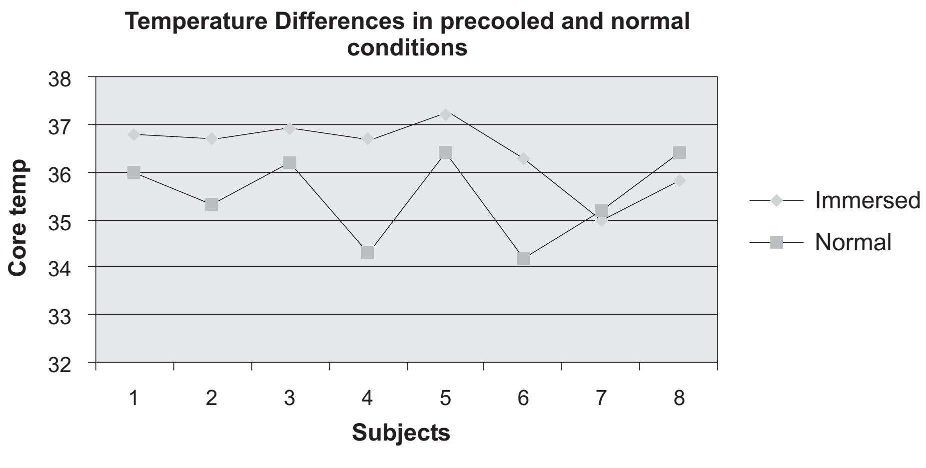
Rating of perceived exertion (RPE)
There was no significant difference in the Rating of Perceived Exertion at the completion of both the normal and pre-cooled tests (P < 0.05).

Initial Data

Heart rate
There was no significant difference in heart rate at the start of both the normal and pre-cooled tests (P < 0.05).

Core Temperature
There was a significant increase in core temperature at the start of the test following pre-cooling (P < 0.05). See Figure 2.

Fig 2 Effect of Pre-cooling on core temperature



Rating of Perceived Exertion (RPE)

There was no significant difference in rate of perceived exertion at the start of both the humid and pre-cooled tests ($P < 0.05$).

Heart rate measures at each additional level above max shuttle reached

Heart rate

There was no significant difference in heart rate in all three subsequent levels above the maximum shuttle reached initially between the pre-cooled and normal state, which is evident due to only a 1.1% increase ($P < 0.05$). See Table 1.

Table 1. No significant differences in heart rate between normal and pre-cooled conditions.

Participant	HR Max 1 Imm	HR Max 1 Hum	HR Max 2 Imm	HR Max 2 Hum	HR Max 3 Imm	HR Max 3 Hum
1	163	164	180	186	186	191
2	164	162	176	176	173	182
3	168	167	172	170	177	180
4	162	164	183	178	NA	NA
5	154	162	168	172	171	173
6	152	163	182	182	189	18 6
7	118	151	170	172	177	178
8	172	174	188	188	NA	NA
Mean	**156,625**	**163.375**	**177.375**	**178**	**178.8333**	**181.666667**
SD	**16.94476**	**6.36816861**	**7.029276**	**6.76123404**	**7.167054**	**6.28225013**

RPE measures at each additional level above max shuttle reached

Rate of perceived exertion (RPE)

There was no significant difference in RPE in all three subsequent levels above the maximum shuttle reached initially between the pre-cooled and normal states ($P < 0.05$).

DISCUSSION

As indicated in the introduction, a beneficial effect of lowered body temperature on endurance performance has been inferred from the adaptive thermoregulatory modifications tending to decrease body temperature in the course of endurance training. The present results extend those observations by showing that high intensity exercise can further be improved by reducing initial body temperatures below those found at thermoneutral conditions.

As for the mechanisms underlying the increased work rate after pre-cooling, it has to be considered that a redistribution of blood volume has been demonstrated to occur during exercise in humid compared with lower temperatures (Rowell et al., 1966). Blood volume is shifted to the skin veins due to the increased venous compliance (Wyndham, 1973). Central blood volume is diminished (Rowell et al., 1966). In addition, a decrease in muscle blood flow during exercise in the heat leading to higher anaerobic energy production has been inferred from the findings that blood lactate started to increase at lower work rates when compared with exercise at lower temperatures (Williams et al., 1962).

The results from the present study revealed that core temperature increased following the pre-cooling manoeuver. The possible reason for this occurrence is that sudden cold exposure (−1ßDC for 3 minutes) results in rapid peripheral vasoconstriction, and warm blood is shunted back to the central circulatory system, causing a spike in deep body temperature. Thus pre-cooling maneuvers (Hessemer et al., 1984: Lee et al., 1995: Olschweski & Bruck, 1988: Schmidt & Bruck, 1981) are characterised by 15–20 minutes of rewarming or transient periods to minimise the rise in deep body temperature and reduce subject discomfort.

Shivering during pre-cooling could be detrimental to exercise performance as muscle glycogen is used as a substrate to fuel the increased metabolic rate (Martineal & Jacobs, 1988).

In the present study, to maximise effects of body cooling on exercise duration, high intensity running was chosen as the exercise mode. Running requires contractions of a larger number of muscle groups than does leg (cycle) exercise or local muscle contractions. High metabolic heat produced by the exercise may overload heat dissipation mechanisms during exercise. Beginning exercise at a high intensity, but not a maximal level, also seems to be critical for enhancing the pre-cooling effect. If participants progressively increase the exercise intensity, the cooling effect on exercise duration seems to disappear (Schmidt & Bruck, 1981).

CONCLUSION

On the basis of the results of the present study, it may be concluded that lower body pre-cooling appeared to increase the duration of high intensity running performance in a thermoneutral environment. This is evident by the 11.56% increase in the number of shuttles (distance) completed by participants after the pre-cooling intervention compared to the normal high intensity running test. In theory the results indicate that pre-cooling has the capacity to enhance high intensity running performance. Such a finding challenges the present paradigm that all high intensity exercise should be preceded by a warm up. It is tentatively suggested that further research is directed to realising a better understanding the benefits of pre-cooling maneuvers for exercise and sporting performance.

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