The role of muscle warmth and passive heat maintenance for optimal competitive performance

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A warm-up is common practice for all athletes and is believed to be essential for attaining optimal athletic performance. The effectiveness of a warm-up strategy typically focuses on the activities performed with little consideration given to the transition phase between warm-up end and competitive event start. During this transition phase, athletes report to a marshaling area generally a minimum of 20 minutes prior to the start of the event with transition phases of up to 60 minutes in major championships.

Coaches often resort to a trial-and-error approach to design their athlete's warm-up strategies, which typically include bouts of exercise varying in intensity, dynamic stretching and technical practice for the proceeding event. There are a number of mechanisms behind why a warm-up works, with the primary factor associated with performance being an increase in body temperature (5), although there are also a number of non-temperature-related mechanisms (1,2). Muscle temperature (T_m) has demonstrated strong associations with power output, with an approximate 4% increase in lower body power output per 1°C increase in T_m (9) (Figure 1). Increases in T_m of approximately 3° to 4°C are required for an optimal warm-up effect (4,8). An active warm-up consisting of moderate-intensity exercise (80–100% of lactate threshold) generally produces rapid increases in T_m within 3 to 5 minutes, which reaches a relative equilibrium after approximately 10 to 20 minutes of exercise (4,8). Therefore, it is important for coaches to consider the timings, duration, intensity and content of the warm-up to maximize its effectiveness.

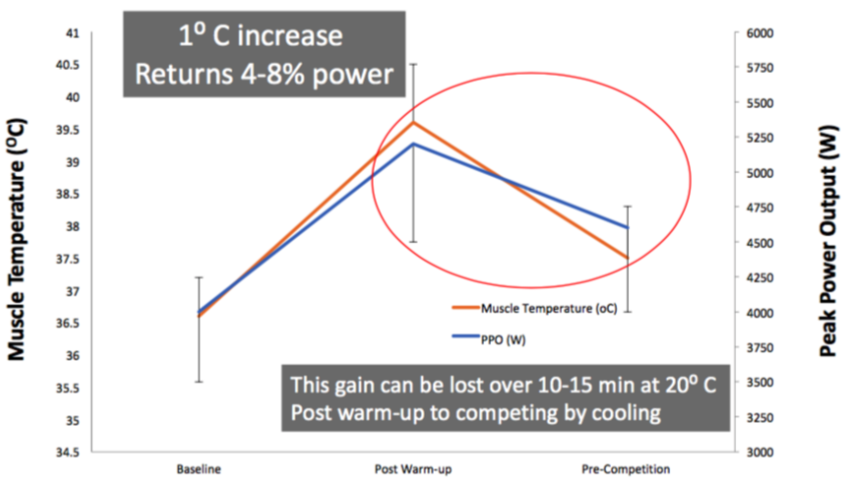

Figure 1. Relationship between muscle temperate and power output across a time period before and after a warm-up.

The transition phase between the end of the warm-up and start of competition is also another important consideration for the athlete and coach. This includes a period of inactivity and has been shown to reflect in substantial decreases in T_m and core temperature (T_{core}) (8,10). For example, a study in international standard swimmers compared post-warm-up recovery periods of 45 and 20 minutes on 200m freestyle performances and reported that T_{core} has returned to baseline after 45 minutes but still remained elevated after 20 minutes. It was also highlighted that of the rise in T_{core} gained through the warm-up, 40% was lost by 20 minutes post-warm-up (Figure 2). This data demonstrates the importance of attenuating the decline in body temperature after the cessation of the warm-up.

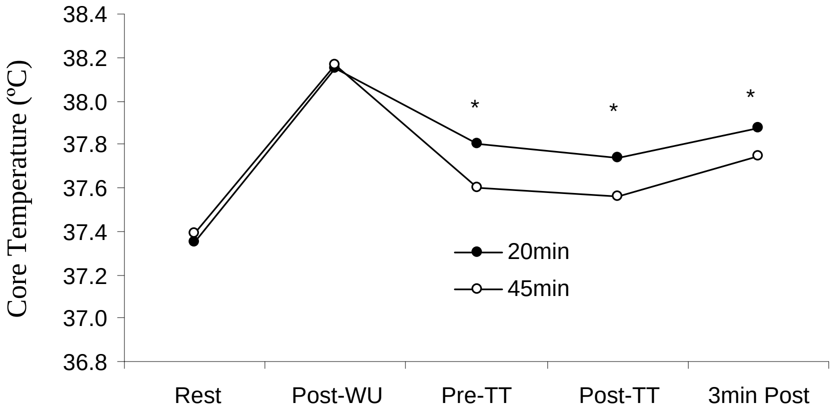

Figure 2. Core temperature of swimmers comparing post warm-up recovery periods of 45 and 20 minutes prior to a time trial (TT) swim.

One such method to help maintain T_{core} and T_m during the post warm up transition phase is through passive heat maintenance (PHM) (6,7). Passive heat maintenance involves the use of an external heat source such as heated clothing, outdoor survival jackets, and heating pads, which can be applied to the desired muscle groups to maintain post-warm-up muscle temperature and, thus, the temperature-mediated pathways that will aid performance (6). For example, in elite bob-skeleton athletes (3), a 65% greater tympanic (ear) temperature was reported when an active warm-up was performed with using an outdoor survival jacket in between warm-up activities and during the period until testing which was also associated with an improvement in 20m sled-sprinting performance, compared with a control condition (room temperature ~20°C). In professional rugby league players, repeated sprint performance and vertical jump performance (peak power) were greater when applying a blizzard survival (full body length) jacket during a 15-minute post-warm-up recovery period than in a control condition (room temperature ~22°C) (6).

Another consideration for field-based athletes is the time between rounds and associated air temperature. Therefore the athlete's clothing attire during their competition has a potential impact on performance. Recent studies (unpublished data) investigated the impact of different clothing attire whilst sitting passively for up to 20 minutes. In the first study (room temperature 15°C) three different clothing options were used; t-shirt and shorts (control), fleece blanket and jumper ($Blanket_{normal}$) and fleece blanket lined with a heat-reflective emergency thermal blanket and jumper ($Blanket_{reflective}$). At 10 minutes of sittings all three conditions showed similar decrements of approximately 1-2% in tympanic temperature. However at 20 minutes of sitting, there was a remarkable difference between all three conditions where the $\text{Blanket}_{\text{reflective}}$ (− 2.5%) was the best intervention followed by $\text{Blanket}_{\text{normal}}$ (− 4.1%) and then the control intervention (− 6.8%). Similar observations have also been noted at 18°C. Of particular note was how the athletes subjectively felt better using a passive heat maintenance garment compared to wearing typical clothing (including wearing tracksuits at 18°C).

Incorporating PHM into your athletes' competition (and training) regime is very affordable. At the entry level, heat-reflective emergency thermal blankets are very accessible and cheap to purchase. Another option is to use heavy-duty foil insulation as a product that can be sewn into blankets and clothing to provide a more innocuous solution for the athlete. It is also important to consider the weather conditions that your athletes are competing in to ascertain the right times to use PHM. Even fluctuations between day and evening temperatures are another important consideration. At the most basic level, even ensuring your athlete has appropriate clothing attire that is worn at the correct times is a simple and practical method to assist with their performance.

In summary, it is evident that increasing body temperature efficiently during the warm-up and maintaining body temperature during the post-warm-up transition phase is vital from subsequent competitive performance. However saying this, the challenge to the coach is applying this information into applied practice. A basic checklist that could be considered when preparing an athlete's pre-competition routine encompassing three main areas:

1. Warm-up
    a. Activities performed
    b. Duration
    c. Intensity
2. Transition phase
    a. Time (how long)
    b. Weather
    c. Clothing attire
3. Competition
    a. Weather – air temperature
    b. Clothing attire worn prior to the start of competition
    c. Field events – time between rounds.

Through systematic forward planning, logging of warm-up routines and transition phases in relation to performance outcome, a more stable physiological platform for optimal performance can be established.

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