

# EXERCISE IN THE COLD

**Tim Cable discusses the physiological responses during exercise in the cold and the implications for football**



Football has become an almost year round activity, with many tournaments played during the summer months and the start of the season is usually accompanied by very warm to hot temperatures. Under these conditions, performance may be adversely affected, as fatigue occurs earlier than when playing in more temperate conditions (see *Insight*, Volume 1, Issue 4). However, it is far more likely that players will experience matches in the cold and wet conditions that predominant from December through to

February. In addition, teams may compete in European destinations close to or within the Artic Circle, where inclement weather conditions may exist in the months of spring. In such environments (i.e. temperatures below 5°C) it is likely that the onset of fatigue will occur earlier than when playing in optimal temperatures of 14-15°C. This earlier onset of fatigue occurs because the single components that make up the physiological demands of football (i.e. endurance capacity, muscle strength and sprint performance) are all adversely affected when the

body is cool or when competing in a cold environmental temperature. The aims in this article are to review the effect of cold on these components, outline some potential differences in response in elite versus non-elite players, and discuss some important considerations when coaching children in cold conditions. Finally, recommendations for a reduction in impact of these factors will be made for training and match-play respectively.

## **Exercise in the Cold**

When exercising in a cold environment research

suggests that endurance capacity is reduced. Galloway et al. (1997) examined the time taken to reach

exhaustion whilst cycling at the same workload in ambient temperatures of 4°C versus 11°C. Although this

research did not use a football specific protocol, it did require individuals to exercise at 70% of their  $VO_{2max}$ , an intensity that reflects that commonly observed in a match situation. In the higher temperature, exercise time to exhaustion was some 94 minutes (again equivalent to the demands of the game), but only 81 minutes at 4°C, a decline in performance of 14%. This reduction in performance was associated with a greater oxygen consumption (and therefore energy expenditure) and a

When playing football in cold conditions, wearing only shorts and football shirt, it is likely that skin temperature will decrease quite markedly. In windy and wet weather, the wind chill factor causes even greater cooling. Such an environment results in a significant reduction in temperature of the limbs, particularly around the thigh. The major consequence of this factor, aside from increased heat loss, is a reduction in the temperature of the underlying muscles. It is known that cooling of skeletal muscle, reduces the force of maximum contraction with a 1°C decrease in muscle temperature causing a 3% decline in power output. Such a fall will impact the performance of those activities that require a high power output (jumping, kicking, sprinting). In addition, cooling of the muscle will dramatically reduce the speed of the biochemical reactions that occur within muscle cells to

faster rate of carbohydrate breakdown. Individuals exercised at a higher percentage of their maximum endurance capacity whilst performing the same work as in the higher temperature. This less efficient effort (i.e. more energy expended for the same output) results in greater breakdown of precious carbohydrate fuel reserves.

Carbohydrate is stored in muscle and the liver as glycogen. When these stores become low or depleted, fatigue occurs rapidly.

produce energy (ATP). The slower speed of reaction will therefore negatively affect the production of energy for sprinting and perhaps more importantly increase the recovery time following a bout of sprinting. The development of speed and maintenance of speed endurance will be affected in the cold. A potential consequence of this effect is that during these brief bouts of very high intensity exercise there will be a greater recruitment of fast twitch muscle fibres in an attempt to compensate for a loss of force. Whilst this may provide greater force development, there will also be an associated increase in lactic acid formation and an even faster rate of glycogen depletion, which may accelerate the onset of fatigue.

A further consequence of a reduction in temperature of the muscles and limbs is that the conduction velocity of

Exercise at the intensity measured in football is known to have a faster rate of breakdown of these essential stores in cold temperatures compared with warmer climatic conditions. The obvious implication of this is that there will be an earlier onset of fatigue. In addition, it is likely that the work rate of players will be adversely affected towards the end of a match played in cold weather, a time when key events are likely to occur.

nerve impulses that supply the muscles and make them contract is reduced. In addition, the velocity of sensory information detected within the muscles themselves (by the muscle spindles) that is then sent back to the brain for processing is reduced. Since both motor information arriving at the muscle and the feedback information are important in producing a skilled and coordinated movement, it is likely that precision and accuracy of movement will be adversely affected, resulting in diminished performance. At low temperatures, synovial fluid in joints becomes more viscous which leads to increased joint stiffness. A combination of altered joint movement and less coordinated movement patterns (particularly in less skilled individuals, i.e. children) may lead to an increased incidence of injury.

## Elite versus non-elite players

Many of the physiological concerns outlined above will likely impact individuals playing at non-elite levels more than the elite. This is because it is likely that the energy demands of match play at the elite level (in all positions except goalkeeper) should be of a sufficient level to provoke a high internal heat production and therefore an increase in core body temperature that will maintain metabolic processes and deep muscle temperature. At the elite level, the paradox may be that even when exercising in cold environments there is still accelerated heat loss from sweating and a consequent reduction in body water stores that must be replaced such that performance is not compromised from dehydration. It is therefore still advisable at this level to monitor weight loss in training and match-play in the winter months so as to counter this possibility. In the non-elite player, and in the goalkeeper at all levels, it is important to ensure that there are adequately protected against the environment as it is likely that their energy expenditure and heat production will be

## Implication for playing in the winter months

Unlike exercise in the heat, there appears to be no exercise performance benefit following acclimatisation to cold (on repeated cold

less. They will be more likely exposed to possible coordination problems and injury potential. In addition, if heat production is not sufficient and the temperature of the limbs falls (and particularly the hands and feet falls), sensation of pain will be reduced. This raises the possibility of continued play with undetected major injury (e.g. metatarsal damage).

## Children and cold stress

Match-play and training continues apace during the winter in age-groups ranging from under 6's to under 16's. Children, particularly in the pre-pubertal years, have different mechanisms of heat loss than adults. As their ratio of body surface area to mass is much larger than in the adult they tend to lose the majority of body heat through the skin, rather than by increasing sweating. In a hot climate this may confer certain advantages (e.g. less dehydration) but in the cold, they are exposed to more rapid heat loss and therefore may risk hypothermia (a fall in body temperature), especially if they are inactive for periods of time as determined by their positional role. In addition, it is

exposure at rest there are changes in local blood flow and metabolism, but these are survival mechanisms, rather than of benefit in a football context). However, there are a number of strategies that coaches can use to ensure that any

important to remember that the body is unable to defend against heat loss from the head (by an inability to reduce skin blood flow to the cranial area), and therefore approximately 25% of all heat loss occurs through this area. It is therefore advised that children play and train in bobble hats/beanies.

A further consequence of playing in the cold, that is not just restricted to children, is a greater incidence of exercise-induced asthma. As cold air enters the mouth, bronchus and other lung tissue it is rapidly warmed and hydrated. This therefore cools and dries the lining of this tissue and increases the risk of bronchoconstriction, the process leads to breathing difficulties and the onset of a potential asthma attack. Exercise-induced asthma is far more common in cold dry environmental conditions than warm and humid conditions, and more common when running than cycling or swimming. In order to avoid these events, players that are susceptible to this condition must make sure they have taken their prophylactic medicine and ensure a long and progressive warm-up.

decrements in performance are limited.

It is vital to ensure that players are at the peak of aerobic fitness before the cold weather appears. This is because a player that has a high endurance capacity

will have increased the activity of those processes that contribute to fat metabolism and therefore will be able to provide a greater contribution to total energy expenditure from fat mobilisation. By definition this will reduce the demand on carbohydrate stores, preserving muscle glycogen and therefore delaying the onset of fatigue. It is also important to stress, that should the season be interrupted by a period of inclement weather, players must maintain their aerobic fitness, so that this benefit is retained.

It is always important to have a good structured warm-up session before matches and training. However, during the

winter this factor assumes even greater significance. If players can enter the field of play with muscle temperature already elevated, it is unlikely that the cold will have a significant impact. This is because muscle temperature can increase to near normal levels as long as exercise begins before muscle is cooled. An adequate warm-up (preferably performed indoors before venturing out) that achieves these aims will therefore reduce the rate of glycogen depletion and maintain force development and also will maintain coordination and patterns of skilled behaviour. During half-time players should be encouraged to keep exercising, at a low intensity, so that body temperature

does not fall and compromise performance immediately on resumption of play.

In addition, insisting that a player commence the match having warmed-up will protect against soft tissue injury. The benefit of such a warm-up could be increased by wearing gloves, long sleeved shirts and cycling shorts to restrict heat loss further. Greater protection will be afforded by playing and training in multiple layers that allow air to become trapped and thereby act as insulation. It is important to use the latest fabric technologies that allow sweat to be transmitted to the environment without compromising the insulation properties of the material.

## Summary

It is well known that performance is adversely affected when performing exercise in the heat. However, the same is also true when exercising in cold environments, as muscle glycogen depletion occurs at a faster rate and the maximal force generating capacity of muscle is diminished. In order to avoid these problems, players should be at the height of their aerobic fitness before the winter period and should perform an adequate warm-up before training or match play.

## Further Reading

Galloway, S.D. and Maughan, R.J. (1997) Effects of ambient temperature on the capacity to perform prolonged cycle exercise in man. *Medicine and Science in Sport and Exercise*, 29, 1240-1249.



