Background
Individuals with sickle cell trait (SCT) have a mutation in one of two genes encoding for the hemoglobin molecule, which carries oxygen in red blood cells. This mutation may cause normally round red blood cells to form a crescent or “sickle” shape in times of low blood oxygen. SCT differs from sickle cell disease, in which both hemoglobin genes are mutated. Sickled red blood cells can block blood vessels and cause damage to muscles and organs; however, sickle cell trait causes far fewer episodes of illness than sickle cell disease. SCT affects more than 300 million people worldwide; in the United States, it is present in 9% of people of African descent, 0.5% of Hispanics, and 0.2% of Caucasians.

Individuals with SCT can typically participate fully in any athletic pursuit. Though SCT rarely impacts athletic performance, under certain circumstances, athletes can suffer negative effects. These include muscle weakness, pain, and collapse. If collapse occurs, it is referred to as Exercise Collapse Associated with Sickle Cell Trait (ECAST). It is important to consider ECAST as a cause of collapse in athletes because the relative risk of death is up to 40 times higher in athletes with SCT than those without. However, early recognition and proper treatment of ECAST can increase survival and decrease complications.

Risk Factors
The reasons for collapse and exertional death with SCT are unclear. Very low muscle oxygen, high body temperature, or dehydration can lead to red blood cell sickling. Exercise rapidly increases blood epinephrine levels, which may cause sickled cells to become “sticky” and block blood vessels. It is unknown why only a small percentage of people with SCT experience ECAST. The following conditions seem to make ECAST episodes more likely:
- Intense exercise over a long time period
- Inadequate rest between intense exercise periods (e.g. prolonged wind sprints)
- Early in athletic season or returning from prolonged rest
- High altitude
- Dehydration
- Excessive heat exposure

Other possible risk factors include high humidity, exercise-induced asthma, pre-exercise fatigue due to illness, and dietary supplements containing stimulants.

Symptoms
Athletes experiencing ECAST may have the following signs and/or symptoms:
- Muscle weakness (greater than muscle pain, though this may also be present)
- Muscle tenderness
- Slumping to the ground
- Rapid breathing
- Temperature usually less than 103 degrees Fahrenheit

ECAST differs from other causes of exercise collapse in several ways. Athletes with muscle cramps will have tight, hard muscles, rather than soft and weak muscles in ECAST. Those with cardiac causes often will not be able to speak or think normally. Athletes with exertional heat stroke will have a core body temperature above 104 degrees Fahrenheit. In ECAST, core body temperature is often normal or only slightly elevated, and athletes will usually speak and think normally.

Sports Medicine Evaluation and Treatment
All collapsed athletes should have their pulses, breathing, and mental status checked. The most telling symptom of ECAST is increasing pain and weakness in muscles, especially the large muscles of the legs, buttock and low back.

If sideline medical staff are concerned an athlete may have ECAST, this should be clearly communicated to emergency room personnel. ECAST can lead to rapid destruction of muscle, a deadly condition called explosive rhabdomyolysis. Treatment includes immediate transport to the hospital for IV fluids and monitoring of electrolytes and heart function.
**Injury Prevention**

The most important way to prevent ECAST is to determine if an athlete has SCT. This is done with a simple blood test. In some cases, this test has already been completed. Newborn screening for hemoglobin diseases was adopted nationwide in 2006. Since 2010, the National Collegiate Athletic Association (NCAA) has required all student athletes to have sickle cell status documented, though athletes can opt out of this requirement.

It is important to use safe exercise practices that decrease the risk of collapse in all athletes, regardless of their sickle cell status. The following are recommended for all athletes, and may help prevent ECAST:

- Take part in exercise and conditioning activities year-round to maintain physical fitness.
- Increase exercise intensity gradually if starting a training regimen or returning to training after an absence, such as an illness or academic break.
- Provide adequate recovery time between repetitive sprints/drills (e.g. wind sprints, intervals, etc.).
- Get acclimated to the altitude or temperature at which training will occur.
- Exercise for shorter time periods and less intensely during hot and/or humid conditions.
- Hydrate well before, during, and after exercise.
- If SCT status is known, understand the signs and symptoms of ECAST. If any symptoms appear, report immediately to training staff, coaches, and/or doctors.

**Return to Play**

Before returning to play, athletes who collapse during exercise and have ECAST signs or symptoms should be tested for SCT. Tests for other diseases such as diabetes, electrolyte abnormalities, muscle damage, and heart and lung conditions may be required. Athletes should meet with a doctor to discuss family history, environmental factors, and medications that increase risk of collapse. They should be educated about signs and symptoms of ECAST, the importance of hydration, and the possibility of future ECAST episodes if exercising heavily in high heat. Athletes must have no symptoms at rest and normal lab values before resuming exercise. Training should resume slowly and under a doctor’s supervision.

**References:**

