Optimising Olympic Distance Triathlon Performance – A Biomechanist's Perspective.

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Optimum competition performance is directly related to maximising the average velocity achieved during the race. From a biomechanical perspective maximising velocity involves optimising technique to increase propulsive force production, optimising technique and equipment to minimise the resisting forces that limit velocity and making tactical and technique decisions which conserve energy or limit reductions in velocity. Biomechanics can contribute to optimising ODT performance in these ways. However, given that there is a direct relationship between the ability to train and the competitive performance, and that failure to achieve optimal training loads is primarily due to injury, biomechanics plays a secondary role in optimising competition performance by helping to keep an athlete injury free.

Since triathlon is an endurance sport, high numbers of running strides, swimming strokes and pedal cycles are undertaken on a routine basis. A small biomechanical inefficiency can soon lead to injury once many thousands of repetitions are encountered in heavy training. Similarly, anatomical anomalies, technique faults, inappropriate equipment and equipment adjustment can lead to injury without large numbers of repetitions if any of these factors introduce large forces to the body. Specific training techniques can also apply high loads to the body. Inappropriate use of these techniques or incorrect management of their frequency and duration can lead to injury. Biomechanics can play a significant role in preventing injury, which can lead directly to enhanced competition performance.

Mechanisms Of Injury In Swimming.

The shoulder is the most common site of injury in swimmers. Impingement of the long head of the biceps and/or the supraspinatus tendons in the shoulder joint is a common mechanism underlying shoulder injury. Flexibility and strength issues and how these relate to movement patterns are primarily associated with impingement injury. Swimmers with reduced flexibility or with strength imbalances, either avoid the shoulder positions and movement patterns which promote a technically efficient stroke, or they achieve the correct stroke pattern by compensating with undesirable movement of the shoulder joint, putting it in a position that may cause impingement. In general, injury prevention occurs if an athlete has the efficient movement which is associated with performance enhancement. Routine assessment of flexibility, the strength of individual muscle groups and stroke technique can identify problems that lead to swimming injury.

Performance Enhancement In Swimming.

Swimming Velocity = Stroke Length X Stroke Frequency

Stroke length is the distance the swimmer moves through the water from right hand entry to right hand entry. The longer the stroke length the more propulsive force produced during the stroke. A swimmer is more efficient if he optimises the force produced throughout the stroke, producing a longer stroke length, than by increasing the stroke frequency as a way of compensating for reduced stroke length. The complete stroke of the swimmer needs to be periodically analysed, to ensure that inefficiencies in technique are not reducing the stroke length.

As well as increasing the forward propulsive forces, swimming speed can be increased by reduction in the resistive forces. Reducing resistive forces is an effective way of improving performance because it requires no extra energy expenditure from the swimmer. The main component of resistive force to the swimmer is due to the shape exposed to the oncoming flow of water. It can be reduced by utilising better technique during propulsive actions and better streamlining during recovery. Another potential areas where biomechanics can improve performance is in optimising the technique and strategy of slipstreaming in the wake of other swimmers to conserve energy.

Mechanisms Of Injury In Cycling.

Cycling is a unique component of triathlon because it involves the interaction of man and machine. The way the athlete interacts with the bicycle is influenced by its dimensions and this influences the loads applied to the body. The gearing system of the bicycle promotes high pedal rates compared with swimming and running and hence large numbers of flexion/extension and pedal loading cycles occur. An athlete undertaking bike training of 10hrs/week will undergo over 50,000 pedal cycles in the week. Any adverse loads placed on the musculoskeletal system even if small can soon manifest as an injury.

The most common site of injury from cycling is the knee joint. However the mechanism that underlies knee joint injury is rarely located at the knee. Bicycle seat height, incorrect gear usage, biomechanical or anatomical anomalies originating in the ankle or the hip are primary causes of knee injury in cycling. The other common site of injury from cycling is the lower back. Contributing factors to this injury include seat height, inappropriate crank length, leg length discrepancy and asymmetry of the riding posture.

Optimising the dimensions of the bicycle for an athlete's individual limb segment lengths, flexibility and pedalling technique is a fundamental aspect of reducing injury from cycling. Similarly, routine biomechanical screening of the riding posture and pedalling technique will identify biomechanical inefficiencies which could lead to injury.

Performance Enhancement In Cycling.

The movement of the lower limbs during cycling is defined and restricted by the bicycle dimensions. Consequently, the development of propulsive forces in cycling is fundamentally linked to the geometry and adjustment of the bicycle.

The riding position and posture affects the lower limb muscle length characteristics, the knee joint mechanics and the pedalling technique. These parameters have to be considered to maximise force production. Unfortunately, they interact such that the optimisation of one parameter may have a negative effect on another. Hence, the biomechanical optimisation of cycling to maximise force production is not about optimising individual components but about balancing conflicting mechanisms to produce the most effective outcome.

As with swimming, reducing the forces that resist forward motion can have as great effect on performance as increasing propulsive forces. The main component of resistive force is that due to the size and shape of the body as it encounters the oncoming air. Because the posture on the bike is influenced by the athlete’s flexibility and is defined by the points of contact with the bicycle, bicycle dimensions and adjustment is also the main factor involving the resistive forces. Since it effects both the propulsive and resistive forces, the optimisation of the riding position is a fundamental component of optimising cycling performance.

In addition to optimising force production, technical and tactical aspects also play a significant role in optimising cycling performance. The bicycle is essentially an unstable machine and it is the rider that keeps the forces in balance to keep it stable. The bicycle is potentially most unstable when the additional forces present during braking and cornering act on the bike. Because the forces of gravity and deceleration act on the Centre of Gravity (C of G) of the bike and rider, the position of the C of G has a large influence on performance during braking and cornering. The position of the C of G is influenced by the bicycle dimensions, the riding position and the technique of the rider. Optimising the position of the C of G will result in higher speeds through corners and less energy expended on keeping the bicycle stable.

Recent rule changes allowing drafting in elite level ODT have fundamentally changed triathlon. Because the resistive forces encountered when riding can drop by as much as 40% when drafting the dynamics of bunch riding greatly change the physical and tactical demands of the bike leg. Power output profiles associated with criterium style riding c.f. time trial riding indicate significantly different physiological and technical demands. This has implication for the optimisation of the riding position, the riding technique and tactical strategy. From an optimisation perspective, bunch riding and the dynamics of drafting have changed triathlon from an individual sport to a team sport. The optimisation of ODT performance now lies in the optimum use of team resources to maximise the performance of a selected individual.

Mechanisms of Injury and Performance Enhancement in Running.

The forces acting on the body during running are higher than those encountered in swimming and cycling. Runners experiencing high impact loads are more likely to get injured than those with lower impacts.
Consequently the attenuation and management of the loads that accompany running play an important role in remaining injury free.

Running shoe construction has a large influence on the foot and ankle movement patterns and the magnitude of the loads transmitted to the lower limb during ground contact. Control of the amount of dorsiflexion and pronation with footwear appropriate for an individual athlete can lessen the likelihood of injury. Similarly, the occurrence of injury is reduced by shoes with midsole construction and pressure distribution characteristics that lessen the transmission of impact forces. Training parameters also influences impact loads. Increased running speed causes a linear increase in impact loads. Running downhill dramatically increases impact as well as moving the point of force application on the foot, enhancing the risk of injury. Contrary to common belief, running on grass increases impact shocks up to 30% above running on asphalt or a polyurethane track surface.

Routine biomechanical assessment of running mechanics, appropriate footwear to control the movement patterns and reduce impact loads as well as informed training decisions that limit the magnitude and frequency of impact loading will help the athlete achieve their training goals by staying injury free.

The relationship between technique and performance is not as strong in running as it is in swimming and cycling. Running techniques that reduce braking forces during initial foot-ground contact have not been clearly shown to improve running efficiency. However runners with large vertical movement of the body's C of G have a higher energy cost and care should be taken to limit these vertical movements.
Potential areas where biomechanics may help optimise running performance is with investigation of the pacing and tactical strategy of the bike leg and its influence on the subsequent run performance. Investigation of power output records associated with the cycle leg may lead to the evolution of an individualised riding strategy that optimises running performance.

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