Acceleration

Acceleration is crucial to peak performance across numerous sports. Forget raw or top speed. Athletes that can increase their speed (i.e. accelerate) more rapidly than their rivals can gain an incredible and often unassailable performance advantage. The most obvious example is the 100m sprinter, who might not attain the highest top speed, but reaches the finish line first because he or she is able to attain their top speed before the other competitors. The same is true in racket and field sports; rugby players and footballers may breach the defence with a searing burst of pace that leaves the opposition for dead, while a racket sport player may accelerate to retrieve a shot that his opponent ‘thought’ was a winner.

So what makes for great acceleration technique? In order to study this, researchers from New Zealand studied the ground reaction forces (GRF) involved in the acceleration sprint phase (1). Thirty-six athletes performed maximal-effort sprints from which video and GRF data were collected at the 16-metre mark. The team discovered that the faster accelerating athletes displayed less vertical impulse in their acceleration phase i.e. more force was directed horizontally, thus pushing them forward. The quicker accelerators also had faster ground contact times. Although acceleration requires greater foot/ground contact times when compared to maximum speed sprinting (to impart sufficient force to overcome inertia), the research indicates that better acceleration derives from quicker ground contacts.

Acceleration and sprinting

In sprinting, a low body position is desirable when leaving the blocks because it enables the athlete to maximise their acceleration. This phase of the race is often described as the part when the sprinter is sprinting with their legs ‘behind their body’ and contrasts with the main ‘flat-out’ part when work is done ‘in front of the body’.

The arms should be pumped vigorously backwards and forwards as the athlete drives from the blocks to gain momentum. Coaches vary in the way they teach the leg movement; some argue for a ‘driving back’ movement of the legs, while others advocate bringing the thighs to the chest in a piston like manner. In both cases however, the body should remain inclined, until around the 15-metre mark, when the sprinter’s torso moves into an increasingly upright position.

In field sports however, it’s obviously far more difficult to execute such a precise accelerative technique. Players will often be off balance and/or may have a ball at their feet or held under their arm. Additionally they may be playing on a soft and slippery surface, which will significantly hamper power generation. Nevertheless, field and racket sport athletes and their coaches can learn much from the techniques harnessed by sprinters for maximum acceleration – notably the low body position and centre of gravity that enables the legs to supply optimum propulsive drive from static position.

However, coaches from these sports should also develop accelerative practices that involve turns. An example of an accelerative practice for field and racket sport players involves two players standing 2m apart. On a command, they turn through 180 degrees and sprint 5m. As a variation, the drill can be performed with 90-degree turns, with players turning in opposite directions.

Training for increased acceleration

It’s often argued that the most specific sports improvements are derived from training practices that closely replicate the movement patterns of the sport in question. This would mean, for example, that plyometric muscular action exercises (such as hopping and bounding) should have a greater relevance to the majority of sports than the more usual concentric/eccentric type of muscular action. However, when it comes to conditioning acceleration, research indicates that it’s not so simple.
Concentric training and acceleration
Researchers from Canada investigated the relationship between sprint start performance (five-metre time) concentric muscle strength and power variables (2). Thirty male athletes performed six 10m sprints from a standing start. Sprint times were recorded, as were the force-time characteristics of the first ground contact (using a recessed force plate).

Three to six days later the subjects completed three loaded concentric jump squats, using a traditional and split-squat technique, with a range of external loads from 30-70% of one repetition maximum (1RM). These exercises require the performer to bend their legs to jump, pause and then jump. In doing this they invoke an almost purely concentric muscular contraction, rather than a plyometric one.

The results showed that athletes who were better at moving the weights during the squat jumps were the best 10m accelerators. This led the researchers to conclude that concentric (not plyometric) force development was critical to sprint start performance and accordingly that maximal concentric jump power was related to sprint acceleration.

To further clarify; the first step from a stationary start (or near stationary position for a field/racket sport player) requires a concentric muscular action. This contrasts to the subsequent sprinting strides that profit from the increased plyometric power opportunities provided, which occurs when the eccentric priming of the subsequent concentric contraction increases power potential, in the muscles of the calves, thighs and hips. Think of it like stretching out a spring to its full extent (the eccentric contraction) and then letting it go. A lot more power is released in the split second the spring recoils (the concentric contraction).

Acceleration and leg stiffness
Most sprint coaches recommend a program of plyometric exercises (See Coaching Newsletter No 9 – May 07), such as hopping and bounding to develop explosive ability (including acceleration) and enhance leg stiffness. Basically the stiffer a sprinter’s (or field/racket sport player’s) legs are, the better able they will be at generating power from the running/playing surface. To provide an analogy, carbon fibre legs will be much stiffer and therefore propulsive than pipe-cleaner legs!

However, a team of French researchers discovered that leg stiffness as measured via a hopping test was not directly proportional to accelerative ability, although it was to flat out speed(4). The acceleration and maximal running velocity developed by eleven subjects over a 40-metre sprint was measured by radar. Leg power was measured by a treadmill test and a hopping test. Each subject performed maximal sprint accelerations on a treadmill equipped with force and speed transducers, which were used to calculate forward power. The hopping test was performed on a force platform. Leg stiffness was calculated using the flight and contact times of the hopping test – i.e. the greater the hop height and the quicker the ground contact, the stiffer the performer’s legs.

What did the researchers find? Treadmill forward leg power was correlated to both the initial acceleration and maximal running velocity during track sprinting. However, leg stiffness calculated from hopping was significantly correlated with maximal velocity but not with acceleration. These findings were corroborated by another French team whose very similar research is particularly interesting in that it involved 19 regional to national level 100m sprinters – rather than non-elite performers(5). These athletes had best times ranging from 10.72 to 12.87 seconds. The 100m sprint was divided into a 0-30m acceleration phase, a 30-60m secondary acceleration to maximum speed phase and a 60-100m speed maintenance phase. This team discovered that their hopping test was the best predictor of the last two phases of the
100m race and that sprinters who had the greatest leg stiffness produced the highest acceleration between the first and the second phases – not the first.

So why is leg stiffness less important for acceleration? The answer is as indicated previously more than likely a response to the fact that concentric muscular strength expression is a key acceleration determinant, while plyometric power – which is enhanced by greater leg stiffness – becomes more relevant to the sprint athlete when they can use a fast eccentric pre-stretching muscular contraction to enhance the power output of the subsequent concentric contraction.

Weighted sleds and acceleration
Athletes from numerous sports tow weighted sleds (or car tyres) loaded with weights over distances from 5-40m in an attempt to improve their acceleration. Variations in standing starts are used, for example, three-point and sprint starts. Achieving a low driving position is particularly important when towing if the athlete is to get in the best position to overcome inertia. The added load will force the athlete to drive hard through their legs and pump vigorously with their arms.

A team of Greek researchers looked specifically at the validity of towing methods as a way of improving both acceleration and sprint speed (6). Eleven students trained using 5kg weighted sleds (the RS group) and 11 without (the US group). Both followed sprint-training programs, which consisted of 4 x 20m and 4 x 50m maximal effort runs. These were performed three times a week for eight weeks. Before and after the training programs the subjects performed a 50-metre sprint test. The students’ running velocity was measured over 0-20m, 20-40m, 40-50m and 0-50m. In addition stride length and stride frequency were evaluated at the third stride in acceleration and between 42-47m during the maximum speed phase.

The researchers discovered that the RS group improved their running velocity over the 0-20m phase i.e. their acceleration improved. However, this acceleration improvement had no effect on their flat out speed. This contrasted with the US group who improved their running velocity over the 20-40m, 40-50m, and 20-50m run sections. This led the researchers to draw the obvious conclusions that, 'Sprint training with a 5kg sled for eight weeks improved acceleration, but un-resisted sprint training improved performance in the maximum speed phase of non-elite athletes. It appears that each phase of sprint run demands a specific training approach.'

However, if sleds are used as a means of improving acceleration, what is the optimum load to tow for maximum training adaptation? Australian researchers from Sydney considered just this (7). Twenty male field sports players completed a series of sprints without resistance and with loads equating to 12.6 and 32.2% of body mass. The team discovered that stride length was significantly reduced by approximately 10 and 24% for each load respectively. Stride frequency also decreased, but not to the same extent as stride length. In addition sled towing increased ground contact time, trunk lean and hip flexion. Upper body results showed an increase in shoulder range of motion with added resistance. Crucially it was discovered that the heavier load generally resulted in a greater disruption to normal acceleration kinematics (sprinting technique) compared with the lighter load. In short, towing heavier weight sleds is unlikely to specifically benefit acceleration.

Over-speed acceleration training
Over-speed training refers to a training condition when an athlete is ‘forced’ into greater limb and body speeds by use of external devices/factors. These include elastic-chord towing devices and downhill runs. Californian researchers looked at the use of elastic-chord towing devices for improving acceleration in nine collegiate sprinters who ran two 20-metre maximal sprints (MS) and towed sprints (TS) (8). In particular, they measured selected kinematics of the acceleration phase of sprinting, which were recorded on high-speed video. One complete stride at the 15-metre point on the fastest trial was digitised for computer analysis.
The team discovered that there were significant differences for horizontal velocity of the centre of mass (CoM), stride length (SL), and horizontal distance from the CoM of the foot, to the CoM of the body for the MSs group compared to the TSs group. However, these differences mitigated against improved acceleration as they were contrary to optimum sprint acceleration requirements; it turned out that due to the pull of the elastic chord, the TSs group was unable to ‘drive their legs’ as effectively as they would without such assistance. The increased forward momentum imparted by the over-speed method prevented them from getting their body and their feet into the required optimum driving position, which meant that the desired leg drive and ‘pushing back’ of the track surface was disrupted.

Summary
Increased acceleration requires a structured approach and the use of specific drills, practices and conditioning. Developing powerful concentric leg strength is crucial, as is using weighted sleds with a relatively light load (5kg). However, plyometric drills (and increased leg stiffness) are increasingly important as strides get longer, and ground contact times reduce as top speeds are approached. Acceleration and top speed running practices and conditioning methods need to be blended into a coherent training plan if an athlete is going to reach their full speed potential. Over-speed methods do not seem to offer real benefit, nor do heavy weight squats jumps or heavy load weighted sleds.

References
7. Strength Cond Res 2003; 17(4):760-7