Augmented eccentric loading: theoretical and practical applications for the strength and conditioning professional

Phil Watkins, BA (Hons), MSc (SES), MSc (S&C), PGCE (Phys. Ed), CSCS, ASCC, PGDipHRMan

Summary
The practice of incorporating augmented eccentric loading (AEL) into resistance exercise is still relatively new. Although limited, there is evidence supporting the contention that AEL may lead to both superior acute and chronic adaptations over more traditional methods. AEL involves coupled concentric and overloaded eccentric muscle actions, and attempts to optimise the muscular adaptations associated with stretch-shortening cycle (SSC) activities. Cluster set configurations may be used as a means for implementing AEL into periodised training plans, and may improve the quality of each AEL repetition when compared with more traditional set structures by offsetting the affects of fatigue. More research into concentric and eccentric relative loading, as well as the rate of eccentric loading is necessary to further define its role within the strength and conditioning community. However, it is possible that enhanced training effects may be achieved if increased eccentric loads are implemented into periodised strength-training programmes.

Introduction
Human movement is made possible through the relative contributions of eccentric, isometric and concentric muscle actions. Muscle forces produced during maximal eccentric actions are greater than during maximal concentric or isometric actions. The combined effect of these actions is termed a stretch-shortening cycle (SSC), where performance may be enhanced by a prior countermovement. The elastic properties of muscles and tendons have been shown to improve performance in SSC movements, (e.g. sprinting and jumping activities), which are characterised by a fast eccentric muscular stretch, immediately followed by a powerful, concentric muscular contraction. A stretch immediately prior to a concentric action, results in increased force production and power output in the concentric phase and a shift in the force-velocity curve. The majority of strength and power programmes however, focus on developing concentric one-repetition maximum (1-RM) strength, and often overlook the benefits of using increased eccentric loads. Additionally, 40–50% greater force can be produced during the eccentric phase compared with the concentric phase, indicating that the eccentric muscle actions are underloaded during traditional isoinertial weight training. An alternative form of strength training, termed augmented eccentric loading (AEL), involves coupled concentric and overloaded eccentric muscle actions, and attempts to optimise the muscular adaptations associated with resistance training. This paper attempts to examine the efficacy of using AEL as an alternative training approach, and provides practical examples for its implementation into a periodised training programme.
Underlying physiological mechanisms of AEL

The underlying muscular adaptations following AEL training have not been fully determined.43 However, five physiological mechanisms have been hypothesised as being potential contributors to enhanced concentric performance following AEL.1,6,18

1. Increased Neural Stimulation

Muscles are forcibly stretched during AEL and their tension rises sharply, resulting in more motor units being recruited.20 Quick and forceful eccentric actions cause increases in the excitability of proprioceptors for an optimal reaction by the neuromuscular system, resulting in a more forceful concentric action. These changes are controlled and counterbalanced, in part, by two proprioceptors most relevant in SSC movements, namely muscle spindles and golgi tendon organs (GTOs).41 Located in the intrafusal fibres and innervated by gamma-motor neurons, muscle spindles are facilitatory mechanoreceptors that react to changes in muscle length to protect the muscle-tendon complex.12 The inevitable unloading of the muscle spindle during muscle shortening is counteracted by a concomitant shortening of the intrafusal muscle fibres. This stretch reflex occurs during the yielding phase, and compensates for muscle exposed to forcible stretches.41 Located in the extrafusal fibres and innervated by alpha motor neurons,20 GTOs act as a protective mechanism that responds to changes in tension, rather than length, inhibiting agonist muscles and facilitating the antagonist muscles. When muscle contractile forces reach a point where damage to the muscle-tendon complex may occur, GTOs increase afferent activity through inhibition of the motor neurons that innervate the stretched muscles, whilst simultaneously exciting the motor neurons of the antagonist muscles.3,34 AEL can upregulate the stretch reflex, as well as reduce the inhibitory reflexes.20,41

2. Stretching of the Parallel and Series Musculotendinous Complex

Elastic energy stored in the series elastic elements (SEE) during the eccentric phase is re-used in the concentric phase.41 An increase in the rate of eccentric loading may result in a brief storage of additional elastic energy, which may be used during the concentric phase. At the on-set of muscle shortening, elastic recoil of these elements adds to the work output of the muscle-tendon complexes involved in these actions.40 Tendon recoil speeds are much greater than muscle shortening speeds, and exercises with increasing stretching loads result in a reduction in muscle activation and surface EMG,5,37 indicating an increased reliance on the elastic properties of the musculotendinous unit (MTU) during ballistic actions.

3. The Elastic Nature of Tendons

Force production increases during the eccentric phase of SSC movements, resulting in the time availability for force development being greater44 than in concentric only movements. There is very little lengthening of the muscles in this eccentric phase, and at the moment of transition (reversibility) from lengthening to shortening, the force is developed under isometric conditions, so the influence of high velocity is avoided.42 A continuation of tendon lengthening enables a body to continue to drop downward.48 MTU stiffness has been shown to play an important role in making full use of the benefits of SSC movements.28 When no external forces are present, these systems maintain a constant shape, however, when acted upon by external forces, they generate elastic force to oppose the external force and store and return elastic energy.29 A stiffer spring-like action in the legs allows humans to run with higher stride frequencies than otherwise possible,4 however, the stiffness of muscle is variable and depends upon the forces exerted. Such tendons work as springs, and allow for storing and recoiling large amounts of mechanical energy.45 Harrison et al.,34 demonstrated that sprinters used a stiffer leg spring at any given velocity when compared with high calibre endurance athletes, but suggested that endurance athletes may benefit from the inclusion of SSC related activities in their training. Superior athletes can develop high forces, and the stiffness of their active muscles exceeds the stiffness of their tendons. It has been proposed that the influence of the facilitatory reflex, which originates from the muscle spindles can be enhanced through training and can improve muscle stiffness.41 The role of the inhibitory force feedback component (from the GTOs), can be simultaneously decreased.23

4. Preloading

Developing pre-tension prior to muscle shortening has been reported in the literature.17,18 AEL may allow a portion of the cross-bridges to be attached before the onset of the concentric action, thereby increasing joint movements early in the concentric phase.1 Concentric movements immediately preceded by isometric or eccentric actions lead to greater concentric torque when compared with purely concentric actions.20,46 According to the force-velocity relationship, force must be developed when velocity is slow in order to achieve very high forces. High levels of muscle activation early in the movement, enable muscles to produce greater forces over a range of joint angles.24 In most high speed movements, muscle forces are developed in isometric conditions6 throughout much of the movement, with the magnitude of lengthening and shortening of muscles depending upon the amplitude of the eccentric and concentric phases, and the muscle involved. This near isometric or quasi-isometric action of the muscles, enables high forces to be generated in accordance with the force-velocity relationship, as well as allowing them to operate near their optimal length.

5. Postactivation Potentiation (PAP)

Fatiguing muscle contractions impair muscle performance, whereas non-fatigued muscle contractions, usually at high loads and short duration, may enhance muscle performance.21 Therefore, postactivation potentiation (PAP) may be defined as an increased twitch contraction force following a maximal voluntary contraction.21 Proposed mechanisms include the phosphorylation of myosin regulatory light chains, rendering actin-myosin more sensitive to Ca2+ release from the sarcoplasmic reticulum during subsequent muscle contractions,22 together with adaptations of reflex activity in the spinal cord.5,18 Theoretically, PAP increases the rate of force development (RFD), leading to increases in velocity and acceleration,26 and may be achieved when eccentric loads are augmented19 during such activities as drop jumping or squatting.
A Brief Literature Review

Augmented Eccentric Loading (AEL) has been defined as ‘the application of a heavy eccentric force immediately prior to a relatively lighter concentric force’. Augmented eccentric loads may be provided by: i) increasing the rate of muscle lengthening, ii) increasing the relative load or iii) through a combination of the two.

Implications for influencing the rate of eccentric loading: Early AEL studies found that performing depth jumps from incrementally higher displacements were more effective at increasing vertical jump height when compared with countermovement jumps. These findings are subject to an athlete’s ability to absorb force upon landing, since the AEL during depth jumping increases accelerative force, impulse (i.e. the product of force (F), and the change in time (\(\Delta t\)) during the application of that force), and the rate of muscle lengthening upon landing. Toumi et al. reported similar findings following a study into the effects of eccentric phase velocity of plyometric training on vertical jump performance. Subjects performed tests for maximal isometric and concentric squat force, as well as squat and countermovement jump displacement, before and after an 8 week experimental speed squat training protocol, with eccentric speeds of 0.2 m/s and 0.4 m/s. Both groups’ squatting and jumping performances improved significantly following the intervention, however, a reduction in the amortisation rate of the speed squat was also reported in the 0.4 m/s group. The superior adaptations of the eccentric loading may be attributed to the increased eccentric loading via the rapid stretch imposed on the muscle.

Hilfiker et al. evaluated the immediate influence of eccentric muscle action on vertical jump performance in thirteen elite Swiss athletes, (i.e. ski jump, ski alpine, snowboard freestyle and alpine, ski freestyle and gymnastics), with a mean age of 22 years (range 20–28). The athletes were randomised into 2 groups, and following a semi-standardised warm-up, group 1 performed five modified drop jumps (i.e. landing with active stabilisation in 90° knee flexion) from a height of 60cm. After a one minute rest, each athlete performed three single squat jumps (SJ) and three single countermovement jumps (CMJ) on a force platform. The procedure was repeated after one hour without the modified drop jumps, and in a cross over manner. Group 2 did the first warm-up without and the second warm-up with the modified drop jumps. Significant increases were found between peak power output during the CMJ, when adding the five modified drop jumps to the warm-up. However, no other significant differences were reported, although large inter-individual variability of the effects were observed, indicating practical significance (i.e. 1cm jump height or a change of 0.5W/kg peak power) in elite athletic populations. Although generalisations to other populations should be treated with caution, the findings are in agreement with other studies, examining the effects of maximal voluntary contractions on vertical jump performance. The authors concluded that athletes performing sports with single actions (e.g. long jumping, ski jumping) requiring a PAP effect, may benefit from the inclusion of modified drop jumps approximately 1 to 5 minutes before the onset of the competition.

Conversely, Moore et al. investigated the acute effects of AEL on squat jump performance. Thirteen resistance-trained men, (age = 22.8 ± 2.9 years), were assessed performing squat jumps under 4 experimental conditions, (condition 1, 30% 1-RM back squat; conditions 2, 3 and 4, squat jumps with a 30% 1-RM subsequent to the application of AEL conditions of 20, 50 and 80% of 1-RM back squat respectively). Results indicated that peak velocity, force and power values obtained during the squat jumps were similar (p<0.05) across all loading conditions. However, the eccentric portion of the jump squat in this study was executed at a relatively slow velocity, serving to reduce any additional accelerative force. Therefore, the rate of eccentric action may be more significant than absolute load, possibly explaining why the loading parameters were ineffective in this study.

Implications for increasing the relative eccentric load

Acute Studies: Doan et al., measured the acute effects of AEL on subsequent concentric 1- repetition maximum (RM) strength in the bench press exercise. Eight moderately trained men, (mean age, 23.9 yrs), performed maximal attempts in the bench press using detaching hooks (i.e., weight releasers), which allowed them to lower 105% of their concentric 1-RM and raise 100%. All subjects significantly (p = 0.008) increased their 1-RMs by 5 to 15 pounds with the mean bench press score increasing from 97.44kg for the normal eccentric condition, to 100.57kg for the AEL condition. Although limited by a lack of sensitive measures, such as force, power and rate of force development (RFD), the results demonstrated that additional eccentric loading may be beneficial in producing acute increases in 1-RM bench press, and may also offer a potentiation effect as part of a warm-up. The loadings used in this study were of particular interest, maximal concentric barbell loads were coupled with a small AEL of 105% of concentric 1-RM, whereas the concentric barbell loadings used by Moore et al. were significantly smaller (30% 1-RM), with AEL ranging from 20 to 80% 1-RM. The authors of this study, suggested the possibility of the existence of a concentric load threshold, below which, AEL may be ineffective at improving performance.

More recent studies have monitored the acute effects of varying dynamic accentuated external resistance, (DAER), on neuromuscular responses, growth hormone and blood lactate concentrations, and force and power responses during the bench press exercise in eleven healthy, physically active resistance trained males, (32 ± 4.3 years; 86.3 ± 8.8kg). Four hypertrophic DAER protocols (i.e. condition 1-70% eccentric and concentric loads (70/70%); condition 2-80/70%; condition 3-90/70% and condition 4-100/70%), and volume (4 sets of 10 repetitions with 2 minutes recovery) were performed. The results indicated that the greatest metabolic and hormonal responses occurred with the 90/70% loading condition, with the optimal eccentric load being 20% larger than the concentric load. These findings may be applied to the programme designs of athletes attempting to optimise gains in muscle hypertrophy and suggest the importance of individualising load selection for DAER exercises. Similarly, protocols with varying DAER loads of 100, 105, 110 and 120% of 1-RM for the eccentric phase, (100% of 1-RM was used
for all concentric phases), and an additional explosive strength session involving repetitions with 50, 60, 70, 80 and 90% of 1-RM loads for the eccentric phase, (50% of 1-RM was used for the concentric phases) were performed\(^\text{31}\) with varying heavy DAER. The data showed that the selected loads did not enhance maximum concentric force production. However, during the explosive actions, although no significant differences were observed between the loading conditions in peak concentric power, the highest peak power was observed during the 70/50% loading condition. Individually, the 77.3 ± 3.2/50% condition produced the highest power output values, and differed significantly (p<0.001) from the control condition of 50/50%. This may be explained by individuals who possess highly trained elastic elements having a larger recovery of stored elastic energy, thereby producing more power with the higher DAER loads, compared to individuals with a lower training status. The authors suggest that individualising DAER loading thresholds is an effective strategy to adopt when optimal concentric power production is required in the bench press. More research using multiple concentric loads across populations is required to confirm if such thresholds exist.

**Chronic Studies:** Brandenburg & Docherty\(^\text{2}\) compared exist. Populations is required to confirm if such thresholds are present. More research using multiple concentric loads across populations is required to confirm if such thresholds exist.

**Table 1: Example cluster set structure for the box squat (i.e. with a load related AEL) during a basic strength phase of a periodised training plan - adapted from Haff.\(^\text{15}\)**

<table>
<thead>
<tr>
<th>Type of Cluster</th>
<th>Exercise</th>
<th>Sets x Repetitions</th>
<th>Cluster set repetition loading structure (i.e. % eccentric/concentric 1-RM/repetition)</th>
<th>Inter-repetition rest interval (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Box Squat with AEL (e.g. use manual or weight releasers)</td>
<td>4-6 x 6/1</td>
<td>105/80/1 105/80/1 105/80/1 105/80/1 105/80/1 105/80/1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-6 x 6/2</td>
<td>105/80/2 105/80/2 105/80/2 105/80/2 105/80/2 105/80/2</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4-6 x 6/3</td>
<td>105/80/3 105/80/3 105/80/3 105/80/3 105/80/3 105/80/3</td>
<td>40</td>
</tr>
</tbody>
</table>

**Notes:**

6/1 = 6 total repetitions broken down into 6 clusters of 1; 6/2 = 6 repetitions broken down into 3 clusters of 2; 6/3 = 6 total repetitions broken down into 2 clusters of 3. In the above example, each set has an average eccentric intensity of 105% of concentric 1-RM and a concentric intensity of 80% of 1-RM for the box squat. These can be periodised over the phase of training. Inter-repetition rest intervals can be shortened or lengthened up to 45 seconds depending upon the training goals and the athlete’s level of development.

During a basic strength phase (Table 1), greater strength gains have been acquired when prescribed eccentric loads have been in excess of the concentric 1-RM (i.e. ~105-120% of the concentric 1-RM). Prescribed concentric loads should be high, (>80% of the athlete’s 1-RM), if the appropriate type II fibres are to be targeted.
training volume and time commitment undertaken by the AEL group, suggests that AEL training maybe more efficient in enhancing anabolic stimuli and strength adaptations relative to total training volume; and so strength trainers with limited training time may also benefit. Additionally, the increased rate of lactate clearance may favour athletes competing above their lactate threshold, (e.g. rowers and wrestlers), as greater delayed lactate accumulation may occur.

**Summary of the Literature**

There is growing evidence to support the hypothesis that AEL may produce superior strength gains, both acutely and chronically, over more traditional methods in untrained and resistance trained populations. However, there is also evidence suggesting that AEL is no more effective than traditional training methods for increasing strength and power across populations. Much of the conflict within the literature may be due to methodological differences, for example, inconsistencies in training volumes/intensities, length of studies, modes of assessment and in particular subject populations. It is likely that AEL adaptations are dependent upon training history, genetics (e.g. fibre type distribution) and trainability. Although no conclusive statement can be made with regards to eccentric-concentric optimal load selection, and concentric performance enhancement, superior gains in strength, power and hypertrophy may be achieved when eccentric loads are in excess of the concentric 1-RM, (i.e. strength ~105-120%; power ~70-80%; hypertrophy ~90%), and when the optimal eccentric load is approximately 20% greater than the concentric load. Faster eccentric actions also contribute, (i.e. rate dependent interactions), to increases in eccentric loading through accentuation of the SSC and the underlying physiological mechanisms, and may enhance concentric performance following AEL. Athletes participating in sports with single, explosive actions (e.g. long jumping, ski jumping or shot putting), and requiring a PAP effect, may benefit the most from the inclusion of high velocity augmented eccentric actions, approximately one to five minutes before the onset of the competition.

More research into the role of concentric and eccentric loading as well as the rate of eccentric loading is necessary. In particular, longitudinal training studies investigating individually based eccentric-concentric loading thresholds across populations. Manipulations to AEL protocols may yield favourable training adaptations with increases in training volume and duration across the training cycle. Coaches and athletes with limited time to participate in resistance exercise may also benefit from AEL, as similar improvements in muscular strength have occurred at lower training volumes and time commitment when compared with more traditional methods. Additionally, AEL may benefit specific muscle groups over others, and may aid recovery in some populations.

**Figure 1.0**: The initial box squat set-up when performed with a load related AEL.

**Figure 1.1**: Augmented loads are removed simultaneously from each end of the bar.

**Figure 1.2**: Finishing position for the box squat with concentric only resistance.
Table 2: Example cluster set structure for plyometric drop jumps (i.e. with a velocity related AEL) during a basic power phase of a periodised training plan.

<table>
<thead>
<tr>
<th>Type of Cluster</th>
<th>Exercise</th>
<th>Sets x Repetitions</th>
<th>Cluster set repetition loading structure (i.e. % eccentric/concentric 1-RM/repetition)</th>
<th>Inter-repetition rest interval (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard 1: As part of a periodised programme</td>
<td>Plyometric Drop Jump with AEL (e.g., using viper belt with bands)</td>
<td>1-3 x 10/1</td>
<td>30/1 30/1 30/1 30/1 30/1 30/1 30/1 30/1 30/1 30/1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-3 x 10/2</td>
<td>30/2 30/2 30/2 30/2 30/2 30/2 30/2 30/2 30/2 30/2</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1-3 x 10/3</td>
<td>30/5 30/5</td>
<td>15</td>
</tr>
<tr>
<td>Standard 2: As part of a warm-up (adapted from Hilfiker et al. 2007)</td>
<td>Modified Drop Jump (i.e. landing only)</td>
<td>1 x 5/1</td>
<td>60/1 60/1 60/1 60/1 60/1 60/1 60/1 60/1 60/1 60/1</td>
<td>No rest</td>
</tr>
</tbody>
</table>

Notes: Standard: 10/1 = 10 total repetitions broken down into 10 clusters of 1; 10/2 = 10 repetitions broken down into 5 clusters of 2; 10/5 = 10 total repetitions broken into 2 clusters of 5. During the eccentric phase, intensity can be altered by changing the height of the box (e.g., 30cm in the above example), or increasing/decreasing the number of bands attached to the belt. The bands are released immediately prior to the concentric phase of the jump. Rest intervals can be lengthened up to 45 seconds depending upon the training goals and training status of the athlete. Warm-Up: 5/1 = 5 repetitions broken down into 5 clusters of 1. The athlete drops from a box height of 60cm (landing only) with no rest between each cluster set. Maybe incorporated into a warm-up 1 to 5 minutes before the onset of competition or training to achieve a PAP effect.

During a basic power phase (Table 2), velocity related AEL activities, (figures 2.0, 2.1 and 2.2), such as drop jumps use rapid powerful movements that are preceded by a pre-loading countermovement. Strength and conditioning coaches should encourage rapid, powerful movements that reduce the eccentric/concentric transition times from their athletes, as well as emphasising the importance of minimising ground contact times.

The implementation of AEL into athlete training

AEL training requires the athlete to perform coupled concentric and overloaded eccentric muscle actions, and the efficacy of using AEL in athlete training appears promising and may be used across populations. Athletes should include a practice phase (e.g. 1-3 sessions), to ensure optimal familiarisation and jumping proficiency, which may assist in overcoming technical flaws and less-than-optimal volition due to the AEL. Examples of exercises that may be adapted for AEL include: squats, drop jumps, jumps in place, squat jumps, lunges, bench press and bench throws. Load related AEL exercises such as the box squat, (in figures 1.0, 1.1 and 1.2), may be implemented without the use of weight releasers. However, this is an advanced resistance training method, with communication between spotters and athletes being the key to safe execution of this exercise. Only advanced resistance trained athletes with appropriate supervision should implement this mode of AEL training into their programmes.

Due to the ‘stop-start’ nature that is often inevitable when performing AEL exercises, (resulting from the inter-repetition ‘set-up’ of bands, dumbbells, weight releasers etc), cluster set configurations may be used as a more structured approach to implementing AEL into a periodised training plan (Tables 1 and 2). Traditionally, a training set is comprised of a series of repetitions performed in a continuous fashion. A cluster set however, may employ a 15-45 second rest period between each repetition, the main manipulation involving modifications to the inter-repetition rest interval, (e.g. 10/1 = 10 total repetitions in the set with the selected inter-repetition rest between each repetition; or 10/2 = 10 total repetitions in the set with the selected inter-repetition rest after each series of 2 repetitions) (Table 2). Other modifications may include variations to individual loading patterns contained in the set, or alternating the number of repetitions employed. The inclusion of inter-repetition rest intervals could improve the quality of individual repetitions when compared with traditional set structures, and offset the affects of fatigue on performance by enabling the athlete to partially recover between each repetition. Manipulations to the cluster repetition scheme, inter-repetition rest interval length and the loading sequence should be matched to the phase of training, training goals, and the performance characteristics of the sport. Exercise selection and progression must be guided by training status as untrained subjects have been reported to respond to the eccentric phase of a high stretch load with a period of inhibition.

General conclusions and recommendations

There is evidence supporting the hypothesis that AEL may produce superior strength gains, both acutely and chronically, over more traditional methods in untrained athletes.
and resistance trained populations. Conflict within the literature may be due to methodological differences such as modes of assessment, subject populations and exercise prescriptions. Exercises that demand variation in movement velocities, coupled concentric and overloaded eccentric muscle actions (AEL), and the targeting of different phases of the SSC, may provide superior performance results in athletes. The efficient use of elastic energy being the key mechanism behind, increases in movement speed, power and efficiency observed in SSC movements. However, the velocity of eccentric loading may be more important than the absolute load based on current research findings.

To assist strength and conditioning coaches with the implementation of AEL into athlete training, superior strength gains have been achieved when eccentric loads have been in excess of the concentric 1-RM (i.e. strength ~105-120%; power ~70-80%; hypertrophy ~90%; and the optimal eccentric load is approximately 20% greater than the concentric load), or when faster eccentric actions attribute to an augmentation in eccentric loading, via the underlying physiological mechanisms that contribute to enhanced concentric performance. Examples of exercises that can be adapted to provide an augmented eccentric load include: plyometric drop jumps, jumps in place, squats, squat jumps, lunges, bench press and bench throws. The inter-repetition rest interval may improve the quality of each AEL repetition, when compared with more traditional set structures by offsetting the affects of fatigue.

More research into concentric and eccentric relative loading as well as the rate of eccentric loading is necessary to further confirm its role within the strength and conditioning community. AEL maybe a suitable occasional alternative to traditional training with athletes during a training or macro cycle, and may have population-specific benefits. It is possible that enhanced training effects could be achieved if increased eccentric loads are implemented into periodised strength-training programmes. Manipulations of AEL protocols may also yield favourable training adaptations as a consequence of increased training volumes implemented within the periodised programme. Athletes and strength trainers with limited time to participate in resistance exercise may also benefit from AEL, as similar improvements in muscular strength have occurred at lower training volumes and time commitment when compared with more traditional methods. It may also aid recovery in some populations. Consideration should be given to exercise selection, variation, training intensity and volumes throughout the programme, as well as the training status of the athlete.

Figure 2.0: Start position for a drop jump when performed with a velocity related AEL.

Figure 2.1: Landing position for a drop jump, bands are released immediately prior to the concentric phase of the jump.

Figure 2.2: Flight phase for a drop jump with velocity related AEL.
References


---

**MSc STRENGTH AND CONDITIONING**

**STARTS OCTOBER 2009**

- Develops student mastery in the design and implementation of sport-specific training programmes
- Prepares students for accreditation by the UKSCA and NSCA
- Provides work experience to increase vocational prospects within elite level sport.

**Special features**
- NCSA and UKSCA exams taken at the University
- Programme includes specialist workshops and symposia
- New S&F training facilities and state of the art testing laboratory
- The programme runs every Wednesday, October to April

**Modules include:**
- Advanced Strength and Conditioning Training
- Applied Physiological and biomechanical Assessment
- Movement Analysis and Corrective Exercise of the Elite Performer
- Research Methods and Dissertation

Find out more at [www.mdx.ac.uk/sport](http://www.mdx.ac.uk/sport)

Call or email today for a copy of our 2009 Entry Postgraduate Prospectus:

**Admissions Enquiries:**
020 8411 5555 • enquiries@mdx.ac.uk

---

UK STRENGTH AND CONDITIONING ASSOCIATION
© UKSCA | Issue 17 | Spring 2010 w: www.uksca.org.uk e: info@uksca.org.uk