Acute performance enhancement in sport

by

Mark Steven Godwin

Canterbury Christ Church University

Thesis submitted for the degree of
Doctor of Philosophy
2024

Abstract

Introduction: Acute performance enhancement can be used in sports performance and during training sessions. Novel methods to acutely increase performance are commonly used in both trained and recreational participants, with varying degrees of efficacy. Traditionally, activities prior to performance were generically described as a warm up and consisted of exercises across a range of intensities, some form of stretching e.g., static or dynamic, plus some technical preparation. Preconditioning activities such as passive heat maintenance, remote ischemic preconditioning and postactivation potentiation (PAP) or post activation performance enhancement (PAPE) can also be used to increase subsequent performance. The latter involves an attempt to acutely enhance the performance of an athlete during each training session or immediately prior to an event and consists of a preconditioning activity.

Aims: (1) To study the reliability of novel resisted sprint equipment. (2) To study the effects of pre-conditioning activities on subsequent acute postactivation performance enhancement (PAPE) with a range of participants.

Methods: A reliability trial of the Run Rocket™ was undertaken to ascertain the ICC and coefficient of variation. Randomised control trials were formulated to look at the effects of pre-conditioning activities on physical performance: resisted sprinting, accentuated eccentric loading and self-myofascial release (foam rolling).

Results: The Run Rocket™ showed a high level of reliability for two resistance levels over short sprint distances with recreationally trained participants (ICC R0 – 0.79 to 0.97, R5 – 0.91 to 0.98). The PAPE effects varied across modalities and outcome measures. There were no significant differences in sprint time, velocity and acceleration for both distances, although some participants exceeded the smallest worthwhile change. Resisted sprinting showed no differences over 5 or 10 m for sprint time, velocity or acceleration. However, there were some individual differences when assessed by the smallest worthwhile difference. Accentuated eccentric loading showed an increase in peak power for both loading conditions compared to the control group. No differences were found for jump height or peak velocity. In the foam rolling study, no differences were found in the performance measures between the groups.

Conclusion: The use of preconditioning activities to evoke a performance enhancement are not supported in this body of work. However, responses to such activities appear to be individualised. From a practitioner perspective, PAPE may be influenced by a range of factors that may need to be manipulated to increase acute athletic performance e.g., strength levels, intensity of preconditioning and rest periods.

Declaration of originality

I hereby declare that Mark Steven Godwin has completed this thesis under the support and guidance of a dedicated team of supervisors at Canterbury Christ Church University for the award of Doctor of Philosophy through the route of PhD by Publication.

This thesis includes four original studies published in peer-reviewed journals. The main theme of this thesis is related to acute performance enhancement in sport. Each study has been granted the appropriate level of ethical approval.

Any details of participants have remained confidential. I have acknowledged the work of others within the text and in the reference list.

Mark Godwin

Contents

Section 1

Section 2

Section 3

Appendices

Annex of submitted studies for examination

Figures and tables

Annex of submitted studies

Study 1	Godwin, M., Matthews, J., Stanhope, E. & Richards, K. (2020). Intra and intersession reliability of the Run Rocket$^{\text{TM}}$ in recreationally trained participants. *Journal of Human Sport and Exercise*, *16*(1). https://doi.org/10.14198/jhse.2021.161.05
Study 2	Godwin, M., Dhone, S., and Newman, M. (2023). Post-activation performance enhancement after resisted sprinting in recreationally active participants: a double-blind randomised crossover trial. *International Journal of Strength and Conditioning*, 3(1). https://doi.org/10.47206/ijsc.v3i1.226
Study 3	Godwin, M., Fearnett, T. & Newman, M. (2021). The Potentiating Response to Accentuated Eccentric Loading in Professional Football Players. *Sports*. 2021; 9(12):160. https://doi.org/10.3390/sports9120160
Study 4	Godwin, M., Stanhope, E., Bateman, J. & Mills, H. (2020). An Acute Bout of Self-Myofascial Release Does Not Affect Drop Jump Performance despite an Increase in Ankle Range of Motion. *Sports*, *8*(3), 37. https://doi.org/10.3390/sports8030037

Glossary of abbreviations

AEL	Accentuated eccentric loading
ATP	Adenosine triphosphate
BM	Body mass
CI	Confidence interval
CMJ	Countermovement jump
CON	Control
CONSORT	Consolidated Standards of Reporting Trials
CV	Coefficient of variation
DOMS	Delayed onset of muscle soreness
EPSP	Excitatory post-synaptic potentials
ES	Effect size
GRADE	Grading of Recommendations Assessment, Development and Evaluation
H-reflex	Hoffman reflex
ICC	Intraclass correlation coefficient
JBI	Joanna Briggs Institute
MDD	Minimal detectable difference
MYLK	Muscle myosin light chain kinase
MVC	Maximal voluntary contraction
PAP	Postactivation potentiation
PAPE	Postactivation performance enhancement
RCT	Randomised control trial
RFD	Rate of force development
RM	Repetition maximum
SEM	Standard error of measurement
SSC	Stretch shortening cycle
SWC	Smallest worthwhile change
$\mathbf{V_{dec}}$	Velocity decrement

1.0 Introduction

Over the past century, there has been an increase in athletic performance (Lippi *et al.*, 2008). However, despite increases in sprint and distance running over the same period, human sport performance appears to have plateaued (Berthelot *et al.*, 2015; Weiss *et al.*, 2016). Similarly, this is true for the animal kingdom, where the overall performance of all species has also plateaued and is observed by a sigmoid curve (Berthelot *et al.*, 2015). Despite the increase in performance in track and field athletics, data between 1900 and 2007 showed heterogeneity across the disciplines. The short sprints, 100 and 400 m, showed less improvement than the throwing events of javelin and shot put (Lippi *et al.*, 2008). Biological sex differences were also observed, with females showing greater increases in performances compared to males (Lippi *et al.*, 2008). The advancement of technological innovations, alongside conditioning, nutrition and medicine may explain the irregular performance progression (Berthelot *et al.*, 2015). However, changes in female performance are non-uniform and differ across sports. By studying the performance of the top ten performers in swimming and athletics for both sexes, Thibault et al. (2010) showed that this gap stabilised to 11.7% in 1982 despite an increase in female participation. Differences in male and female performance are not straightforward. Hallam and Amorim (2022) gave seven factors that may explain differences (physiological, anatomical, neuromuscular, biomechanical, sociocultural, psychological, and sport-specific). Each of these factors may contribute to performances in sprint events, middle- and long-distance events (Hallam and Amorim, 2022).

Differences in elite performers can be small. For example, world championship podium finishers in the 100 m sprint in 2009 showed a 1.6 and 3.3% decrease in average sprinting velocities (Prieske *et al.*, 2020). Similarly, in Olympic rowing, differences between the winners and second place can be as little as 1% (Turnes *et al.*, 2019). Therefore, any legitimate methods to increase performance are paramount to all those involved in sports performance. This can involve both long term strategies and acute performance enhancement. The latter involves an attempt to acutely enhance the performance of an athlete during each training session or immediately prior to an event via a process known as postactivation performance enhancement (PAPE). Evidence has shown equivocal results for several methods, despite their popularity amongst the athletic population across all levels of performance from recreational to elite.

This thesis is split into three sections. Section one provides the contextual background to acutely increasing athletic performance across a range of levels and sports using preconditioning activities to elicit PAPE. A review of postactivation potentiation (PAP), its underpinning physiology and proposed mechanisms, is followed by the more commonly studied PAPE phenomenon. The remainder of this first section reviews accentuated eccentric loading, myofascial release and the research methodology used in the submitted studies. The subsequent studies provide evidence and contribute to the body of evidence relating to the efficacy of novel stimuli (preconditioning) for acute performance enhancement.

The second section critically appraises the submitted studies, firstly on the reliability of a commercially available resisted sprint equipment over short sprint distances (study 1) and its subsequent use as a preconditioning activity to induce PAPE using recreationally trained individuals (study 2). The third study looked at the effects of accentuated eccentric loading on vertical jump performance in professional soccer players (study 3) with the final study looking at the effects of self-myofascial release (foam rolling) on vertical jump performance (study 4).

Section three discusses the research findings in the context of new knowledge and practical application to the athletic community. In particular, a discussion of the application of findings to sports. Finally, recommendations for future studies and the implications for physical preparation coaches are presented.

1.1 Athletic development and acute performance enhancement

1.1.1 History of athletic training

Athletic training can be traced back to the time of Hippocrates where physical education formed part of a Greek youth’s training (Snook, 1984). The story of Milo of Croton and his routine of lifting a bull daily from its birth, may show the first account of progressive overload (Snook, 1984) and periodisation is still a key factor of athletic training today (Stone *et al.*, 2021). Seen as a method to manage training variables for adaptation(s) to occur, periodisation is formed by the logical sequencing of fitness and recovery periods to achieve performance goals (Stone *et al.*, 2021). Based on Matveyev's model that was developed after following the preparation of Soviet athletes for Olympic Games in the 1950's, periodisation remains the predominant training approach for athletes (González-Ravé *et al.*, 2022). Blocks or training phases can cover different durations and can include daily sessions (Hartmann *et al.*, 2015). To maximise responses and subsequent adaptations in individual sessions, numerous legal methods have been employed by conditioning coaches. These have included nutritional interventions e.g., caffeine (Southward, Rutherfurd-Markwick and Ali, 2018; Guest *et al.*, 2021), extracellular buffering supplements (de Oliveira *et al.*, 2022), creatine, beta-alanine and nitrate (Maughan, 2018); blood flow restriction ; and postactivation potentiation (PAP) activities (Seitz and Haff, 2016; Dobbs *et al.*, 2019; Tian *et al.*, 2022).

1.1.2 Postactivation potentiation (PAP)

Underpinning physiology and proposed mechanisms of PAP

Postactivation potentiation is a term given to an acute enhancement of performance as a direct result of the contractile history of muscle (Baudry and Duchateau, 2007; Tillin and Bishop, 2009). The methods to evoke it and muscle characteristics have an influence on the magnitude of PAP (Hamada, Sale and MacDougall, 2000). Skeletal muscle contraction occurs via transmembrane proteins (ion channels) that exist in two conformations; (1) active - an open channel and (2) inactive - a closed channel (Marks, Klingmüller and Müller-Decker, 2017). The ion that acts as a second messenger and can change the membrane potential is Ca^{2+} which plays a role in both the stimulus-secretion and stimulus-contraction coupling in both nerve and muscle cells (Marks, Klingmüller and Müller-Decker, 2017). Skeletal muscle summation and tetany occurs via twitch response, summation or tetanus (Preston and Wilson, 2013). Twitch responses occur via a single action potential that causes a twitch contraction, with minimal development of muscle tension. Ca^{+} is released in the sarcoplasmic reticulum which causes a single twitch contraction (Preston and Wilson, 2013). Additional action potentials, that are delivered quickly, add to the initial Ca+ and the concentration in the sarcoplasmic reticulum is increased, causing multiple spikes. Muscle tension is increased due to the increase in Ca+ and the corresponding increase in crossbridge cycling. This event is known as summation (Preston and Wilson, 2013). Finally, to produce a maximal contraction, sarcoplasmic reticulum levels of Ca^+ are required to be high and the muscle does not fully relax. The tetanus contraction remains at maximal levels due to this burst of high frequency action potentials (Preston and Wilson, 2013).

The PAP phenomena relate to post-tetanic potentiation (induced by an involuntary contraction), or postactivation potentiation which occurs via a voluntary contraction (Tillin and Bishop, 2009). It has been reported that an increase in muscular force production can occur via a number of pre-contraction activities. The three identified activities are a maximal voluntary contraction (MVC), an evoked tetanic contraction or the repetition of sub-fusion stimuli (Hodgson, Docherty and Robbins, 2005) and the potentiation therefore takes place on a muscular level (Xenofondos, Anthi, Patikas, Dimitrios, and Kotzamandis, Christos, 2014). The proposed and adopted mechanism of this phenomena appears to be the phosphorylation of myosin regulatory light chains (Brown and Loeb, 1999; Hamada, Sale and MacDougall, 2000; Hodgson, Docherty and Robbins, 2005; Ryder *et al.*, 2007; Tillin and Bishop, 2009). This process involves the binding of the regulatory light chains to a phosphorus molecule with light chain kinase acting as the catalysing enzyme. During muscle contraction when Ca^{2+} is released from the sarcoplasmic reticulum these kinases are activated using the P_i of ATP (Xenofondos et al., 2014).

During a maximum voluntary contraction, the contractile proteins become more sensitive to Ca^+ (Hamada, Sale and MacDougall, 2000; Hodgson, Docherty and Robbins, 2005). A specific Ca^{2+}/calmodulin-dependent serine-threonine protein kinase, skeletal muscle myosin light chain kinase (skMLCK), phosphorylates the regulatory light chain of sarcomeric myosin (Stull, Kamm and Vandenboom, 2011). A member of the Ca^{2+}/calmodulin-dependent protein kinase family, MLCKs express tissue and substrate specific kinases through four different MYLK genes. Specifically, the gene MYLK2 expresses skMLCK in fast twitch fibres of skeletal muscle (Stull, Kamm and Vandenboom, 2011). In myosin thick filaments, cross bridges move away from the backbone which leads to force-producing states at an increased rate (Zhi *et al.*, 2005). However, as this has been shown in skinned fibres and not in intact skeletal muscle, this contribution remains unknown (Zhi *et al.*, 2005). This structural change positively alters the movement between non-force producing to force-producing states of the myosin cross-bridges (Hodgson, Docherty and Robbins, 2005). Subsequently, there is an increase in twitch force and the rate of this force development (Baudry and Duchateau, 2007).

In addition to the proposed mechanism of the phosphorylation of myosin light chains, a theoretical link exists between the Hoffman reflex (H-reflex) and an increase in force production (Hodgson, Docherty and Robbins, 2005). From a neural perspective, the nervous system can change both the number of motor units recruited and the firing rate that leads to an increase or decrease of muscle contraction intensity (Xenofondos et al., 2014). This H-reflex mechanism is linked to the recruitment of larger, high-threshold, fast motor units, that optimise the reflex contribution to neural drive (Hodgson, Docherty and Robbins, 2005). Induced by electrical stimulation of Ia afferents, this monosynaptic reflex may be affected by contractile history (Hodgson, Docherty and Robbins, 2005). Different to the mechanically induced spinal stretch reflex, the H-reflex does not go via the muscle spindles and measures the efficacy of synaptic transmission (Palmieri, Ingersoll and Hoffman, 2004). However, the end result of α-motorneuron twitch response if the same as the stretch reflex (Palmieri, Ingersoll and Hoffman, 2004). Described as PAP or reflex potentiation, frequencies >100Hz are needed in humans to provide a potentiation (Hodgson, Docherty and Robbins, 2005). An increase in post-synaptic potentials has been seen following induced tetanic isometric contractions in animals (Tillin and Bishop, 2009). This increase is the same for subsequent activity with the same pre-synaptic potential. Early work by Lüscher, Ruenzel and Henneman (1983) measured excitatory post-synaptic potentials (EPSPs) in felines. Prior to their work, a belief was held that an impulse in a parent fibre reached all of its synapses (Lüscher, Ruenzel and Henneman, 1983). However, transmission failure may occur in the parent Ia fibre, its terminal arborisation, synaptic knobs and transmitter release mechanisms (Lüscher, Ruenzel and Henneman, 1983). In their study observing the effect of tetanic contractions, Lüscher, Ruenzel and Henneman (1983) reported that a decreased transmitter failure occurred at primarily larger motoneurons, and the result was a PAP effect. In turn, the increase in higher order motoneuron recruitment may enhance performance due to the contribution from fast-twitch muscle fibres (Tillin and Bishop, 2009). However, the authors also suggest that this remains equivocal in voluntary contractions (Tillin and Bishop, 2009).

In summary, PAP mechanisms proposed are associated with the phosphorylation of myosin regulatory light chains and a potential increase in recruitment of larger motor units. There may also be a contribution of neural mechanisms that can affect the intensity of muscle contraction and increase the potentiating effect. Mechanisms of PAP relate to increases in isometric twitch peak force following a conditioning contractile activity that can be either electronically evoked or by voluntary contraction (Sale, 2002; Blazevich and Babault, 2019).

1.1.3 Postactivation performance enhancement (PAPE)

Clarity of terminology and use of PAPE

Inconsistency of terminology exists in the literature and is due to the reporting of mechanistic versus performance outcomes within studies. This inconsistency may lead to the results of studies being misinterpreted (Prieske *et al.*, 2020). For clarity, the term postactivation performance enhancement (PAPE) has been suggested to be used where the outcome measure is performance related and does not include PAP measures, e.g., muscular force/torque production following an electrically-evoked twitch (Prieske *et al.*, 2020). The potential factors that distinguish between PAP and PAPE have been described by Blazevich and Babault (2019) with the latter being attributed to muscle temperature, muscle and muscle fibre water content and muscle activation (Figure 1). Therefore, the resisted sprint, accentuated eccentric loading and self-myofascial release studies in this thesis relate to PAPE and not PAP. These studies contribute to sport specific outcome measures in an applied context and are relevant to practitioners.

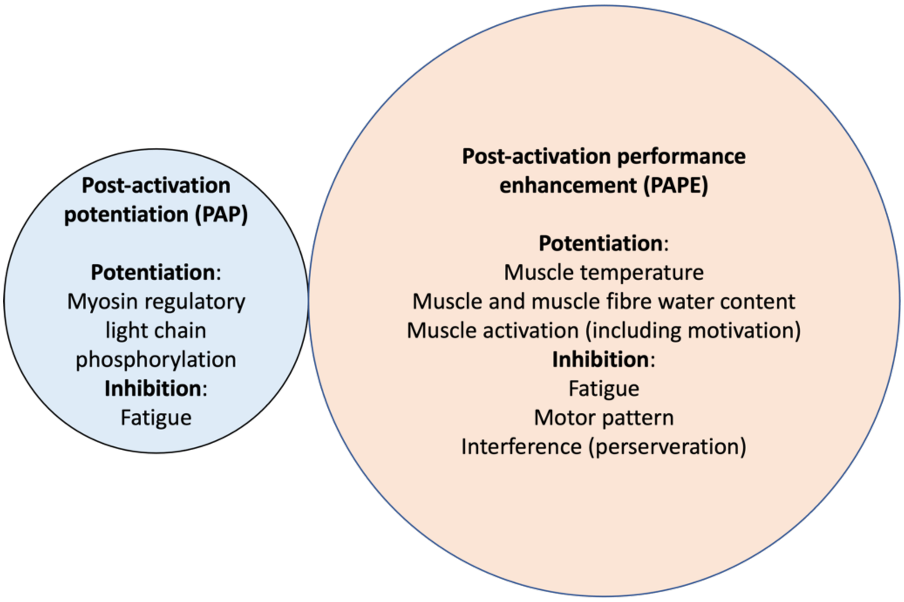

Figure 1. Different proposed mechanisms for PAP and PAPE (adapted from Blazevich and Babault, 2019).

1.1.4 Accentuated eccentric loading (AEL)

Physiology of eccentric loading and mechanisms of AEL

The use of eccentric resistance training has been well documented and involves lengthening of muscle tissue against an external load (Suchomel *et al.*, 2019). During this muscle action, the force produced by the muscle is less that the applied load which results in a lengthening action (Douglas *et al.*, 2017). This differs to concentric and isometric muscle actions whereby the muscle provides tension during shortening and no change in length (Suchomel *et al.*, 2019). In human movement such as downhill walking or running, eccentric muscle actions are commonly used to decelerate and absorb energy (Vogt and Hoppeler, 2014). These isotonic movements or exercises are created by working against the action of gravity and can be undertaken using body weight or additional load to provide braking and antigravity movements (Isner-Horobeti *et al.*, 2013). The mechanical function of eccentric muscle activity can be placed into two categories: shock absorber or elastic spring (Vogt and Hoppeler, 2014). The latter is characterised by a movement cycle that includes the stretch shortening cycle (SSC) and is classed as slow (contact time

>250 ms) or fast (contact time <250 ms) (Vogt and Hoppeler, 2014). Due to the increase in force production capability of eccentric muscle action compared to concentric, there remains scope to provide additional stimuli during the eccentric phase of an exercise. With eccentric strength showing a 50% increase in force production, strength coaches can attempt to minimise the deficit between the two muscle actions (Merrigan *et al.*, 2022). This theoretical model of the concentric strength deficit can be seen in Figure 2. Methods to incorporate eccentric muscle actions into resistance training include tempo eccentric training, flywheel inertial training, plyometric training and AEL (Suchomel *et al.*, 2019).

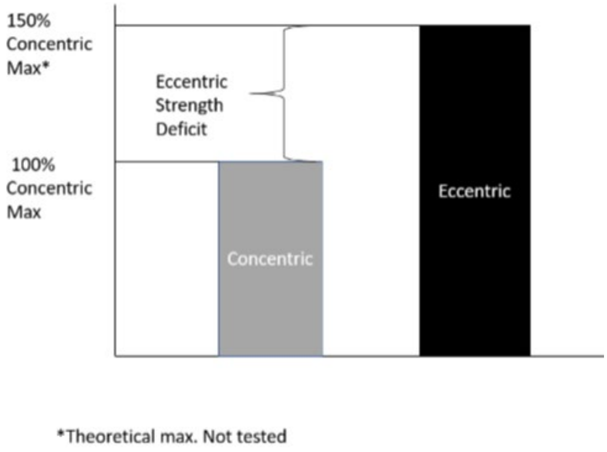

Figure 2. Concentric strength deficit (Merrigan *et al.*, 2022).

An example of including eccentric strength training is seen in the work of Alonso-Fernandez, Docampo-Blanco and Martinez-Fernandez (2018). Using the Nordic hamstring curl to provide an eccentric load to the hamstring muscle group, results of this 13-week trial showed that muscle fascicle length significantly increased following an 8-week training intervention compared to the starting length. Furthermore, following a 4-week detraining period, fascicle length significantly decreased compared to the post-intervention length (Alonso-Fernandez, Docampo-Blanco and Martinez-Fernandez, 2018). There are practical implications for fascicle length and performance. In addition to muscle fibre type distribution, macroscopic muscle traits, such as fascicle length, may play a role in power production and economy of performance (Cooper *et al*., 2021). It has been suggested that maximal muscle power can be enhanced by having a greater number of sarcomeres in series, which in turn, increases the maximal shortening velocity (Kruse *et al*., 2021). This is explained via the length-force relationship of muscles (Figure 3) (Kruse *et al*., 2021). Therefore, a change in fascicle length may be a desired outcome for performance enhancement. Kumagai *et al*. (2000) showed that fascicle length discriminated between levels of male sprinters. The faster of the two groups had significantly greater fascicle length of lower limb muscles, compared to the slower group. This difference was also significantly correlated with sprint performance for the vastus lateralis (r= -0.43), gastrocnemius medialis (r= -0.44), and gastrocnemius lateralis (r= -0.57). In a similar study, Abe *et al*. (2001) reported that a longer fascicle length was significantly greater in female sprinters, compared to a control group for the vastus lateralis and gastrocnemius lateralis. This difference in fascicle length was negatively correlated with 100 m sprint time (vastus lateralis, r= -0.51, gastrocnemius lateralis, r= -0.44). Between these two studies, no differences were found in muscle fascicle lengths for males and females for absolute or relative fascicle length (Kruse *et al*., 2001; Kumagai *et al*., 2000). For endurance athletes, an increase in fascicle length may not be a desired outcome, as longer lengths may negatively affect running economy (Cooper *et al*., 2021; Fletcher and MacIntosh, 2017).

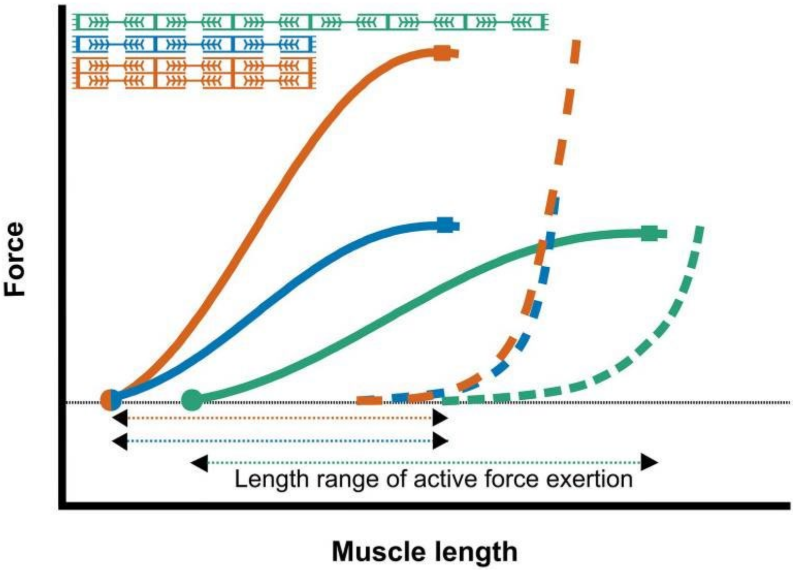

Figure 3. Muscle length-force relationship (Kruse *et al*., 2021).

Eccentrically biased exercise differs to that of flywheel inertial training where the spinning of a flywheel is progressively increased during the concentric phase of the movement via a strap. At the end of this phase, the flywheel continues to spin due to inertia, and the strap rewinds around the wheel providing an eccentric load

(Buonsenso *et al.*, 2023). A limited number of studies has shown this method as a potential way to prevent injuries (Askling, Karlsson and Thorstensson, 2003; De Hoyo *et al.*, 2015). However, a growing number of studies has shown this method to be effective in strength, power and sprint performance (Coratella *et al.*, 2019; Fiorilli *et al.*, 2020; Sagelv *et al.*, 2020; Timmins *et al.*, 2021; Pecci *et al.*, 2023).

Accentuated eccentric loading is a method of training that overloads the eccentric component of an action in movements where coupled eccentric and concentric actions take place (Wagle *et al.*, 2017). Evidence reports that myosin heavy chain isoforms are recruited that may enhance force and power production (Wagle *et al.*, 2017). From a potentiation perspective, increasing the rate of the eccentric contraction and SSC impulse by an increase of the eccentric load, a subsequent enhancement in concentric force and power has been demonstrated (Wagle *et al.*, 2017). Examples of methods to provide this eccentric overload are weight releasers (Doan *et al.*, 2002; Moore *et al.*, 2007a; Ojasto and Häkkinen, 2009; Sheppard and Young, 2010), elastic bands (Aboodarda *et al.*, 2013) and manual adjustment by the participant or coach (Hortobagyi *et al.*, 2001; Brandenburg and Docherty, 2002; Sheppard *et al.*, 2008; Bridgeman *et al.*, 2017). AEL can be applied both chronically (Walker *et al.*, 2016, 2020) or acutely (Sheppard *et al.*, 2008; Bridgeman *et al.*, 2017; Tseng *et al.*, 2021).

Practical application of AEL and athletic development

A consensus has yet to be established on the use of AEL to acutely enhance performance. However, Merrigan *et al.* (2022) have provided a framework for loading strategies that consider the relative strength of the athlete (Table 1). Like other training methods, the manipulation of variables and the status of the participant are highly likely to play a role in the responses. For example, Aboodarda *et al.* (2013) used elastic resistance to provide the eccentric overload component during a countermovement jump in male, plyometric trained participants. Attached via a hip harness and held either side of the participants by an assistant, the loads used in the study were stretched to provide an additional vertical load of 20 or 30% body mass. Using these two loading strategies compared to an unweighted (free) countermovement jump, results showed significant increases in a range of variables for the 30% condition. Peak power, mean power, jump height, relative net impulse and normalised rate of force development were significantly greater than the free CMJ. The only variable showing a significant increase for the 20% condition compared to the free CMJ was jump height (Aboodarda *et al.*, 2013). In a following study using resistance bands to provide the same increase in vertical load (20 and 30%), Aboodarda *et al.* (2014) found no differences in jump height following eccentrically overloaded drop jumps across three drop jump heights (20, 35 and 50 cm). Another simple method to provide additional load during the eccentric phase of a jump is the use of an external load carried by the participant. Sheppard *et al.* (2008) had participants hold a weight plate in each hand (10 kg) that was released at the end of the eccentric phase, immediately prior to the volleyball block-jump. A significant difference with moderate effect sizes (ES) was found for jump height, peak power, peak force and peak velocity (ES 0.2, 0.39, 0.19 and 0.25, respectively) for male high-performance volleyball players. Performance enhancement in these two examples were explained differently. In the earlier study, Sheppard *et al.* (2008) suggest that the increase in jump height could be due to an increased stretch of the intrafusal muscle fibres, which eventually led to larger efferent impulses to the extrafusal fibres. The result of this is a greater contraction of the muscle and was demonstrated by an increase in the force production, compared to the control condition (Sheppard *et al.*, 2008). They also discuss the possibility of an increase in the storage and utilisation of elastic energy stored in the parallel and series elastic components of the muscle-tendon unit (Sheppard *et al.*, 2008). Aboodarda *et al.* (2013) showed a greater production of concentric force at the start of the upward phase (concentric) with accompanying greater extension of the series elastic component. They discuss that an increase in jump height may be obtained by increasing ground reaction force and decreasing vertical displacement so that leg stiffness increases. However, as there was also a significant increase in vertical displacement of the hip, thereby discounting the contribution of the stretch reflex and contractile elements (Aboordarda *et al*., 2013). Despite different proposed mechanisms to explain increases in performance in plyometric-trained individuals and volleyball players, Moore *et al.* (2007) showed no benefit of adding additional eccentric loads on jump squats using weight releasers with loads of 20, 50 and 80% 1RM with heavy-resistance trained individuals. Adding these loads to 30% 1RM concentric load did not affect barbell velocity, force, power or rate of force development (RFD). They discuss how exercise selection and specific loading parameters may impact any potentiation by four proposed mechanisms: (1) increase neural stimulation, (2) parallel and series elastic components stretching, (3) greater tendon elongation and (4) early cross-bridge attachment (Moore *et al.*, 2007). Briefly, an increase in neural stimulation may evoke an increase in motor unit recruitment via muscle spindle activation, leading to a greater muscle contraction via an enhanced myotatic reflex (Moore *et al*., 2007). The storage of elastic energy due to the eccentric contractions may increase the subsequent concentric action, and a greater tendon elongation decreases myofibrillar displacement, that leads to an increase in force production due to a slower recoil velocity (Moore *et al*., 2007). Early cross-bridge attachment may allow earlier binding of actin and myosin that changes and enhances force production (Moore *et al*., 2007). With the level of athlete considered, untrained individuals may not benefit from this type of loading strategy. Weaker athletes may not be able to control the eccentric loading at higher velocities and this action may invoke protective mechanisms to limit potential muscle-tendon damage (Merrigan *et al.*, 2022). However, it is unclear how much influence the Golgi tendon organs play in this mechanism, if they are greater for less trained individuals, and if they diminish following heavy resistance training (Merrigan *et al*., 2022). Therefore, the use of AEL with this population may not be beneficial if there is a supramaximal load of the eccentric phase of the exercise (Merrigan *et al.*, 2022).

Accentuated eccentric loading is not yet fully understood, in fact the neural contribution can only be postulated (Wagle *et al.*, 2017). Methods to apply the increased eccentric load differ across studies e.g., dumbbells, elastic bands and weight releasers (Moore *et al.*, 2007; Sheppard *et al.*, 2008; Sheppard and Young, 2010; Aboodarda *et al.*, 2014) with differing outcome measures and results. Despite a lack of evidence relating to its use, Merrigan *et al.* (2022) note its popularity and have recommended loading strategies for both submaximal and maximal AEL for relatively weaker and stronger athletes (Merrigan *et al.*, 2022).

Table 1. Recommended loading strategies for AEL (Adapted from Merrigan *et al.,* 2022).

	Submaximal AEL		Submaximal AEL		Maximal AEL		Supramaximal AEL	
Less training experience and AEL familiarity More training experience and AEL familiarity	Eccentric loads	Concentric loads	Eccentric loads	Concentric loads	Eccentric loads	Concentric loads	Eccentric loads	Concentric loads
	20% BM – 30% BM	BM	60% - 90%	30% - 50%	100%	30%-80%	105%-120%	30%-90%
	Dumbbells, bands, kettlebells: CMJ, drop, depth jumps		Weight releasers: Bench throws Back squat Front squat Bench press		Weight releasers: Back squat Front squat Bench press		Weight releasers: Back squat Front squat Bench press	
	Relatively weaker <1.5 bench press <2.0 back squat				Relatively stronger >1.5 bench press >2.0 back squat			

1.1.5 Self-myofascial release

Proposed mechanisms and underpinning physiology of myofascial release

The genesis of this treatment modality is attributed to a course entitled ‘Myofascial release’ at Michigan State University in 1981 (McKenney *et al.*, 2013). Numerous methods of treatment collectively come under this term and the technique can be passively used by a therapist or actively by the patient (McKenney *et al.*, 2013). Self-myofascial release is therefore an active therapeutic intervention where the pressure applied to the muscle and fascia, is performed by the individual and not the therapist or clinician (Beardsley and Škarabot, 2015). Human connective tissue, made of different types of collagen, also contains numerous types of sensory receptors e.g., Golgi tendon organs, Pacinian corpuscles and Ruffini’s corpuscles (Freiwald *et al.*, 2016). The role of the fascial connective tissue has been linked with the distribution and transmission of muscle force to adjacent muscles, the skeleton and internal organs (Freiwald *et al.*, 2016). These roles have developed the hypothesis that any restrictions to this fascia in one part of the body may affect the fascial continuity elsewhere in the body (Ajimsha, Al-Mudahka and Al-Madzha, 2015). A recent consensus statement defines a difference between the fascial system and the morphological/histological definition of fascia (Zügel *et al.*, 2018). The former refers to a three-dimensional continuum of connective tissue that allows body systems to function integratedly (Zügel *et al.*, 2018). The latter refers to fascia as ‘a sheet or any other dissectible aggregations of connective tissue that forms beneath the skin to attach, enclose, and separate muscles and other internal organs’ (Zügel *et al.*, 2018). Foam rolling, a method of self-myofascial release, provides a mechanical stimulus to the underlying tissues and is commonly used as a method to provide specific treatment for numerous objectives (Freiwald *et al.*, 2016).

Evidence has shown its effects on range of movement, reducing muscle soreness (DOMS), endothelial function, and autonomic nervous system modification (Beardsley and Škarabot, 2015). Hughes and Ramer (2019) postulated three potential effects of foam rolling: (1) a reduction in fascial adhesions, (2) an improvement in fascial viscosity and (3) changes in the responses of the mechanoreceptors of the myofascial unit. Others have attributed the effects of foam rolling to several parameters, including mechanical, neurological, physiological and psychophysiological (Wiewelhove *et al.*, 2019). Other authors theorise the mechanical mechanisms associated with foam rolling to be an alteration of the viscoelastic properties of the fascia by numerous mechanisms (Kelly and Beardsley, 2016). These alterations may be due to the pressure that is applied by the foam roller, or other implement, that affects the material properties. From a neurophysiological perspective, mechanical pressure can invoke a response from the Golgi tendon organs and other mechanoreceptors that relax tissue and thereby increase flexibility (Kelly and Beardsley, 2016).

However, the mechanisms by which increases in range of movement have been suggested, also exist in general warm up activities (Warneke *et al.*, 2023). The authors further suggest that any increases in range of movement cannot be exclusively attributed to foam rolling (Warneke *et al.*, 2023). Therefore, any competing parameters should be removed if foam rolling is being attributed to an increase in range of motion (Warneke *et al.*, 2023). Studies that compared foam rolling to a control condition i.e., not active, lack external validity and may have little value in the practical application of this intervention.

In addition to changes in range of motion, self-myofascial release has been linked to changes in tissue stiffness (Glänzel *et al.,* 2023). Tissue stiffness is its resistance to deformation and is measured by its elastic modulus (Wells, 2013). This potential change in stiffness to the myofascial tissue could affect both the production of force and its effect on the related bone tissue (Glänzel *et al.,* 2023). In activities involving the stretch shortening cycle, quicker contractile tissue shortening may increase performance (Kubo, Kanehisa and Fukunage, 2005). Whereas muscle strength can be increased due to enhanced transmission of force when the elastic component is less compliant (Wilson, Murphy and Pryor, 1994). Therefore, foam rolling may have the ability to increase, limit or have no effect on performance (Glänzel *et al.,* 2023).

Myofascial release and performance

Commonly starting at the proximal part of the muscle and working towards the distal end, the athlete performs small undulations back and forth over the designated area (Kalichman and Ben David, 2017). Generally, the application of the self-myofascial release last between 30-60 s and is ideal for treating the larger muscle groups (Kalichman and Ben David, 2017). For example, in a 2019 study looking at the effects of self-myofascial release on performance, the foam rolling protocol consisted of 30 s of rolling on the hip flexors and quadriceps, adductors, tensor fascia latae and gluteus, hamstrings, plantarflexors and dorsiflexors (Richman, Tyo and Nicks, 2019). This protocol is similar to the study by Peacock *et al.* (2014) which was used as the basis for the study in this thesis (Study 4). The duration of 30 s was chosen as this reflects the real-world application of foam rolling.

From a performance enhancement perspective, foam rolling prior to activity has been studied in relation to sprint performance (Mikesky *et al.*, 2002; Healey *et al.*, 2014; Peacock *et al.*, 2014; Phillips, J *et al.*, 2018), jump performance (Mikesky *et al.*, 2002; Healey *et al.*, 2014; Peacock *et al.*, 2014; Jones *et al.*, 2015; Sağiroğlu, 2017; Grabow *et al.*, 2018; Phillips *et al.*, 2018), strength performance (Mikesky *et al.*, 2002; MacDonald *et al.*, 2013; Sullivan *et al.*, 2013; Healey *et al.*, 2014; Peacock *et al.*, 2014; Cavanaugh *et al.*, 2017; Grabow *et al.*, 2018) and flexibility (Mikesky *et al.*, 2002; MacDonald *et al.*, 2013; Peacock *et al.*, 2014; Bushell, Dawson and Webster, 2015; Murray *et al.*, 2016; Griefahn *et al.*, 2017; Sağiroğlu, 2017; Cheatham and Stull, 2018; Grabow *et al.*, 2018; Phillips, J *et al.*, 2018). Overall, these studies provide evidence that foam rolling before an activity elicits varying results. There is support for foam rolling to be used in the short term to increase range of movement, with no detrimental effect on performance (Wiewelhove *et al.*, 2019). The small result in pre-foam rolling on sprint performance equated to +0.7%. The effects of pre-foam rolling on jump performance yielded an effect size of 0.09 (0.14, 0.31) (p = 0.45), and for pre-foam rolling on strength performance an effect size of 0.12 (-0.12, 0.37) (p = 0.33) was observed (Wiewelhove *et al.*, 2019).

Foam rolling is a popular amongst athletes and has been anecdotally used to increase performance. However, the systematic review by Wiewelhove *et al*. (2019)

showed that pre-foam rolling had a small effect on a range of performance outcomes. If the desired outcome is an increase in range of motion, self-myofascial release using a foam roller, may be beneficial. There does not appear to be sufficient evidence to promote this intervention when sprinting, jumping or strength performance is required (Wiewelhove *et al.*, 2019).

1.1.6 Resisted sprinting

Whilst the mechanisms for acute performance enhancement via PAP and PAPE have been discussed previously and relate to the performance of a muscle following a previous conditioning activity, results from resisted sprint PAPE studies are limited and varied. The practical rationale for the use of resisted sprinting to enhance performance may lie in the concept of dynamic correspondence (Brearley and Bishop, 2019). For practitioners, prescribing activities that meet some or all of the dynamic correspondence criteria, may be a goal of their programming. Resisted sprinting is simply achieved by attaching a method of resistance that would reduce the velocity and acceleration of the participant. However, methods to prescribe the loads vary and can be given as an absolute value (Van Den Tillaar, Teixeira and Marinho, 2017), a percentage of body mass (Thompson et al., 2021; Winwood et al., 2016) or a decrement in sprinting velocity (Zisi et al., 2022).

In addition to the varying methods of prescribing loads for resisted sprinting, research has been conducted with a range of participants e.g., international level, national handball level, varsity-level sprinters, resistance-trained rugby athletes, junior sprinters, and physically active participants (Whelan, O'Regan and Harrison, 2014; Winwood *et al.*, 2016; Van Den Tillaar, Teixeira and Marinho, 2017; Thompson *et al.*, 2021; Zisi *et al.*, 2022; Kotuła *et al.*, 2023). When comparing the effects of resisted sprinting using a percentage of body mass to prescribe the load, Kotula *et al.* (2023) and Winwood *et al.* (2016) found a significant decrease in sprint time over shorter sprints (30 m flying sprint and 15 m sprints respectively). Using 10% of body mass, participants performed 4 sets of 40 m resisted sprints compared to assisted and combination conditioning activities (Kotula *et al.,* 2023). Significant differences were found immediately and 48 hr following the activity for the flying 30 m sprint (ES 0.28 and 0.22, respectively). A similar effect size (ES 0.22) was reported by

Winwood *et al.* (2016), where a significant difference was found following heavy sled pulls equivalent to 75% body mass (ES 0.22). No significant differences were found for 150% of body mass, or body mass alone. By contrast, Thompson *et al.* (2021) showed no changes and no results greater than the smallest worthwhile change when using 45% of body mass as a conditioning load. A 5 kg load was used by Van Den Tillaar, Teixeira and Marinho (2017) as this was reported to be more practical, rather than using loads based on individual percentages of body mass. Participants performed alternating sprints with additional resistance and body mass only, seven in total. A significant decrease in sprint time was shown after the first resisted sprint only that equated to a 2% improvement ($\eta 2 \geq 0.02$), in experienced female handball players. The use of a decrement in velocity (V_{dec}) can also be used to prescribe the load in resisted sprinting. Zisi *et al.* (2022) used 50% V_{dec} with twelve junior sprinters over 2 repetitions of 20 m and then recorded subsequent 30 m sprint performance. Significant increases in velocity across multiple 5 m intervals ($\eta 2$ range 0.32 to 0.40) and a decrease in 30 m sprint time were found (ES 0.48).

The heterogeneity of participants may influence an overall effect size and make conclusions and recommendations difficult. However, in a systematic review and meta-analysis with elite sprinters, Loturco *et al.* (2024) did find that using resisted sprinting as a conditioning activity did not enhance sprint performance over shorter (20 m) or longer distances (60 m). Therefore, the use of resisted sprinting as a mechanism to induce a performance enhancement may be influenced by numerous factors, including the training status of the athlete and the load.

1.2 Aims and objectives

This research aimed to investigate if athletic performance could be acutely enhanced by studying:

- The reliability of a novel, commercially available resisted sprint equipment on sprint performance (Run Rocket)
- If postactivation performance enhancement (PAPE) could be achieved using resisted sprints as a preconditioning activity for sprint performance using the Run Rocket
- The acute effects of self-myofascial release (foam rolling) on vertical jump performance
- The acute effects of accentuated eccentric loading (AEL) on vertical jump performance in professional soccer players

1.2.1 Research methodology

In the first study, a reliability trial of a novel resisted sprint equipment was undertaken. The Run Rocket was purchased by the institution to be used with student athlete scholars and external athletes. This equipment forms part of the exercise prescription based on the needs analysis of the athlete(s) across a number of sports e.g., rugby, basketball, netball and athletics. The level of athlete varied across the sports, but the majority of participants came from trained and recreationally active cohorts. Therefore, the trial used participants from this demographic to assess the reliability of the Run Rocket. From a practical viewpoint, it is acknowledged that there is a need to assess reliability across a range of demographics and over a variety of distances depending on the level and characteristics of the participants.

Indicating the variability of biological and technical protocols, reliability is an important measure in sport and exercise science (Currell and Jeukendrup, 2008). Relating to measurement consistency, reliability can be attributed to three areas: homogeneity, equivalence and stability (Heale and Twycross, 2015). The reproducibility of the observed result during a subsequent measurement is known as retest reliability (Hopkins, 2000) and reflects both the agreement between measures and the degree of correlation (Koo and Li, 2016). The precision of estimates of change of a variable in an experimental study is affected by within-subject variance, making it the most crucial sort of reliability measure for researchers (Hopkins, 2000). The intraclass correlation coefficient (ICC) is a measure that reflects both the agreement between measures, the degree of correlation and is subsequently a desirable measure. It is used to evaluate interrater, test-retest and intrarater reliability (Koo and Li, 2016) (Table 2).

Table 2. Definitions of different types of reliability (Koo and Li, 2016)

Types	Definitions
Interrater reliability	It reflects the variation between 2 or more raters who measure the same group of subjects.
Test-retest reliability	It reflects the variation in measurements taken by an instrument on the same subject under the same conditions. It is generally indicative of reliability in situations when raters are not involved or rater effect is neglectable, such as self-report survey instrument.
Intrarater reliability	It reflects the variation of data measured by 1 rater across 2 or more trials.

For the Run Rocket study, the ICC was used to assess the reliability of the novel resisted sprint equipment. There was no known published reliability of this equipment at the time of the study. For this study, predesigned spreadsheets were used to assess reliability (Hopkins, 2015). The ICC and associated 90% confidence intervals (CI) were used as an estimate for test-retest reliability. In addition, the coefficient of variation (CV) was calculated and subsequently expressed as a percentage of the mean (%CV). Finally, both the standard error of measurement (SEM) and the minimal detectable difference (MDD) were calculated using the following formulae:

$$SEM = SD\sqrt{1 - ICC}$$

$$MDD = SEM \times 1.96 \times \sqrt{2}$$

A %CV of <10% was interpreted as small (Bradshaw *et al.*, 2010). Combining the ICC and %CV for average variability was interpreted as small (ICC >0.67 and CV <10%), moderate (ICC <0.67 and CV>10%) and large (ICC <0.67 and CV >10%) (Bridgeman *et al.*, 2016). To report the scale of magnitude for effect, results were rated as trivial (<0.1), small (0.1-0.29), moderate (0.3-0.49), large (0.5-0.69), very large (0.7-0.89) or nearly perfect (0.9-0.99) (Hopkins, 2002).

For the subsequent studies, randomised controlled trials formed the basis of the research methodology. Developed to discover the unpredictable and unknown responses to treatment, the randomised control trial (RCT) has two basic principles. Firstly, two or more therapeutic treatments are observed under controlled conditions and secondly, statistics are used to analyse the possibility of error (Meldrum, 2000). The three features of a randomised control trial are that they have control groups, they randomly allocate to treatment, and they are blinded to the participants (Meldrum, 2000). The role of the randomised control trial is seen in medicine as part of the evidence-based decision-making process where research evidence, patients' preferences and actions, and clinical state and circumstances are factors (Devereaux and Yusuf, 2003). In the applied field of human performance, a key aim is to use exercise prescription to improve athletes' performance (Beato, 2022). Recommendations for the use of RCTs in the field of strength and conditioning have been suggested by Beato (2022) and follow the guidance from the Consolidated Standards of Reporting Trials (CONSORT) (Moher *et al.*, 2010). The randomised control trial sits towards the top of the hierarchy of evidence pyramid and is likely to have less bias and fewer systematic errors (Burns, Rohrich and Chung, 2011).

However, these evidence pyramids have been challenged with modifications suggested (Murad *et al.*, 2016). Figure 4 shows two proposed evidence-based pyramids (B and C) from Murad and colleagues (2016) that have been adapted from the original concept (A). In B, the rigid lines delineating between the types of evidence have been replaced with wavy lines. This is to highlight that the quality of evidence from each type of study design can move upwards and downwards, and is based around the Grading of Recommendations Assessment, Development and Evaluation (GRADE). A RCT that has been negatively rated due to limitations of the trials can be seen as less quality of evidence compared to a high-quality cohort study, for example. The removal of the systematic reviews and meta-analyses in C, has been proposed to allow better appraisal and application of the included studies in the review (Murad *et al*., 2016). The authors highlight that the credibility of the systematic review is based on the process by which it is formed e.g., search criteria and inclusion/exclusion criteria. If this initial process is credible, then the evidence presented can be evaluated using the GRADE approach. They liken this approach to viewing other studies through the lens of a systematic review and use the overall effect as a tool to apply the evidence (Murad *et al*., 2016). Despite this slight adjustment to the hierarchical structure of the original evidence pyramid, high quality RCTs are seen as important in research as they are designed to be less biased by randomising confounding factors (Burns, Rohrich and Chung, 2011). When assessing the levels of evidence, the Centre for Evidence-Based Medicine places an individual RCT (with a narrow confidence interval) at level 1a and a low quality RCT at 2b from a possible 10-point scale (CEBM, 2009).

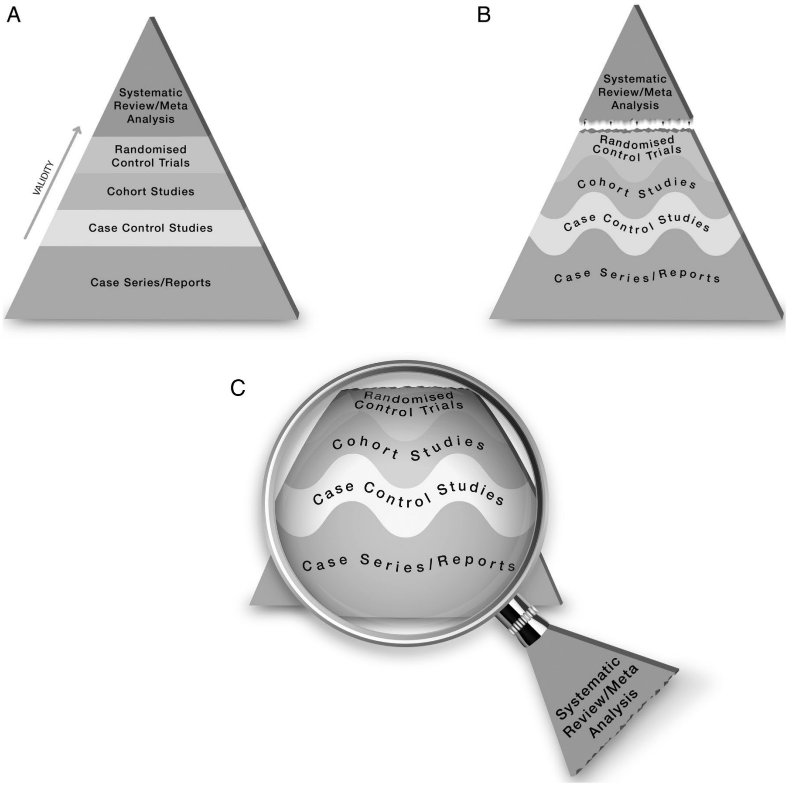

Figure 4 (Murad *et al*., 2016)

Therefore, to assess the quality of the RCTs and provide a critical review of the submissions, a published appraisal tool was used. This appraisal tool assesses the risk of bias for randomized controlled trials (Barker *et al.*, 2023).

The smallest worthwhile change (SWC) was used in the second study to assess the smallest change in performance that can be accepted as real (Turner *et al.*, 2015). This means that a meaningful improvement needs to be of large enough magnitude i.e., the minimum improvement that is likely to have an impact on the field (Buchheit, 2018). Buchheit (2018) suggested methods to derive the SWC with examples of data, type of analysis, method of data analysis and elite level values. Based in his paper, physical performance in team sports for relevant measures e.g., CMJ and sprint times should be measured using the 1/5 of between-athlete standard deviation. Therefore, the between-subject standard deviation, multiplied by 0.2 was used to calculate the SWC (Buchheit, 2018; Turner *et al*., 2015). This value can be compared to the coefficient of variation (CV), expressed as a percentage of consistency (Turner *et al*., 2015). If the value obtained for each individual falls outside of the error range (CV), then a real difference can be inferred. Turner *et al.* (2015) also shows that using 2 times the CV may be used to identify the first real change in performance. However, it is not clear what informs the decision to use either method, and the authors suggest that this is up to the coach. To further add to the discussion, Marocolo *et al.* (2019) acknowledge and support the use of the SWC but offer a choice of two values to use with different level of participants. They propose that 0.2 can be used for participants with a high level of fitness, whereas 0.6 could be used for high and low fitness levels (Marocolo *et al.,* 2019). This is based on the premise that a small effect size within a less-trained population may have less practical benefit compared to elite counterparts (Marocolo *et al.,* 2019). By providing the SWC, alongside null hypothesis testing and effect sizes, readers can make their own judgments about the results and interpretation of the study. These changes can also be quantified as small, moderate, large or very large based on the 1x, 3x, 6x and 10x SWC, respectively (Buchheit, 2018).

The resisted sprint study used a similar population to that used in the reliability trial. Based on the premise that the majority of equipment use would be with a similar demographic, recruitment was sourced from recreationally active participants. A double-blind methodology was used so that participants were unaware of the loading and the lead researcher was supplied with coded data at the end of the trials. This was introduced to limit potential bias.

Study design and recruitment for the self-myofascial release study were similar to the Run Rocket study. A randomised control trial was used to assign participants to one of two groups. The addition of the standardised warm up was used as there was limited data comparing standard practice i.e., a warmup alone, to a warmup plus SMR. From a study design perspective, it was acknowledged that the blinding of participants was impossible, and this may have increased the risk of bias. However, future studies may wish to limit the pressure applied to each participant, despite this being problematic and not replicating the practical application of SMR.

Professional football players were used in the AEL study. This was based on work between the institution and the football club. The sample size of the study was attributed to the squad size and may have been greater than the *a priori* calculation. This was due to the head coach requesting that all players take part in the study. This study design highlights the practical nature of working with professional athletes and the conflicts in study design that may be faced. A randomised control trial was still used, and the athletes were blinded to the external loads used in the experimental condition.

2.0 Critical appraisal of submitted studies

This section provides a critical appraisal of the submitted studies. To apply critical appraisal of the reliability trial, guidance from Bialocerkowski and colleague was used (Bialocerkowski, Klupp and Bragge, 2010). They recommend assessing this type of observational study against a series of questions that help readers critically appraise reliability studies (Bialocerkowski, Klupp and Bragge, 2010). Eight critical questions cover random error, heterogeneity, participant stability, appropriate time periods, meaningful presentation, and generalisability of results. To assess the quality of the randomised control trials, the Joanna Briggs Institute (JBI) Critical Appraisal Tools for use in JBI Systematic Reviews: The revised JBI critical appraisal tool for the assessment of risk of bias for randomized controlled trials was used (Barker *et al.*, 2023). This appraisal tool is used to assess certain categories of validity and domains of bias and consists of thirteen questions (Barker *et al*., 2023).

Table 3. Submitted articles.

Study 1	Godwin, M., Matthews, J., Stanhope, E., & Richards, K. (2020). Intra and intersession reliability of the Run Rocket^{TM} in recreationally trained participants. *Journal of Human Sport and Exercise*, *16*(1). https://doi.org/10.14198/jhse.2021.161.05
Study 2	Godwin, M., Dhone, S., and Newman, M. (2023). Post-activation performance enhancement after resisted sprinting in recreationally active participants: a double-blind randomised crossover trial. *International Journal of Strength and Conditioning*, 3(1). https://doi.org/10.47206/ijsc.v3i1.226
Study 3	Godwin MS, Fearnett T, Newman MA. (2021). The Potentiating Response to Accentuated Eccentric Loading in Professional Football Players. *Sports*. 2021; 9(12):160. https://doi.org/10.3390/sports9120160
Study 4	Godwin, M., Stanhope, E., Bateman, J., & Mills, H. (2020). An Acute Bout of Self-Myofascial Release Does Not Affect Drop Jump Performance despite an Increase in Ankle Range of Motion. *Sports*, *8*(3), 37. https://doi.org/10.3390/sports8030037

2.1 Study 1

Godwin, M., Matthews, J., Stanhope, E., & Richards, K. (2020). Intra and intersession reliability of the Run Rocket^{TM} in recreationally trained participants. *Journal of Human Sport and Exercise*, *16*(1).

The aim of this study was to assess the intra and intersession reliability of the commercially available resisted sprint equipment to prescribe a loading strategy for a preconditioning study (Study 2). The loading strategies for resisted sprint training can be given by an absolute value (kg or N) or by a percentage of velocity decrement. To the knowledge of the author and from personal correspondence from the manufacturer, the Run Rocket had not had any reliability assessment assessed or published. The Run Rocket is a commercially available resisted sprint equipment that comprises of a nylon cord wrapped around a flywheel that is mechanically braked by adjusting the friction via a manual knob. Overcoming the inertia of the flywheel allows the athlete to perform a resisted sprint movement. The athlete is attached to the equipment via a harness worn over the shoulders and around the waist. The equipment can be set to 30 levels of resistance, displayed digitally. The numbers on the display screen are arbitrary and do not relate to any given load e.g., kg or N. The two resistance levels were chosen following exploratory research using sports students. Therefore, this study looked at the reliability of the Run Rocket to decrease sprint velocity which could then be used in resisted sprint training sessions or as a preconditioning activity.

The reliability trial took place using a convenience sample of undergraduate sports students (*n* =14) that were contacted via an announcement on the institutional learning management system. The study took place over two sessions so that intra and intersession reliability could be calculated. The order was randomised, and all data collection was blind to the participants and the lead researcher. The two resistance settings were chosen based on previous experimental work with a population of recreationally active participants.

Statistical analysis was predominantly undertaken using pre-designed spreadsheets (Hopkins, 2015), with all data log transformed to estimate similar errors across the results. For the minimal resistance (R0) the ICC ranged between 0.79 and 0.97 with associated %CV ranging between 2.4-4.6%. For the R5 resistance, the ICC ranged between 0.91-0.98, with the corresponding %CV range of 2.5-5.8%. Variability for both resistance settings and distances was classified as small (Bridgeman *et al.*, 2016).

Assessing the quality and applying critical appraisal to a reliability trial is not straightforward. Considered as an observational study, critical appraisal tools lack specificity when applying them to reliability studies (Bialocerkowski, Klupp and Bragge, 2010). However, Bialocerkowski, Klupp and Bragge (2010) suggests eight critical appraisal questions that can be specifically applied to this type of study (Table 4).

Table 4. Critical appraisal of Run Rocket reliability trial (adapted from Bialocerkowski, Klupp and Bragge, 2010).

	Question	Y/N/NC*	Page on publication
1.	Is the aim of the study clear and appropriate?	Y	2, 3
2.	Was the study sample appropriate?	Y	3
3.	Were a broad range of values generated for the target measurement?	NC	-
4.	Did the researchers minimise random error in their methodology?	Y	4
5.	Were clinically stable participants used in the study?	Y	3
6.	Was the period of time between measurements appropriate?	Y	4
7.	Are the results meaningful?	Y	5
8.	Can the results be generalised to my clinical/research context?	Y	5

*Y – yes, N – no, NC – not clear.

Using the suggested critical appraisal questions, this study was deemed to be of sufficient quality with minimal risk of bias. There was a clear aim of the study with sufficient information in the introduction to justify the importance of the study. In particular, the study was original as there was no other reliability data on this equipment. The sample used in the study was drawn from recreationally active individuals and, linked to question 8, the results can only be applied to this population. Generalising these results across the wider sporting population is therefore not recommended and each specific population should generate a new set of reliability measures. Random error was limited by a number of factors. The Brower timing gate system has been shown to be a valid and reliable way to measure time in a similar population (Shalfawi *et al.*, 2012). A comprehensive familiarisation was given to the participants, with three practice attempts with the Run Rocket at differing resistance levels. All participants received the same verbal instructions throughout the trials, and all testing took place at approximately the same time in the same indoor facility. A standardised warm up was completed that was taken by the same researcher. The resistance levels were randomised and blinded to the participant and lead researcher. Finally, there was an appropriate time frame between the testing trials that reduced any change of health status that may have affected the repeated measures reliability trial.

The Run Rocket is a relatively inexpensive resisted sprint equipment used to provide overload for linear movement. Results from this study showed that over short sprint distances common in team sports, reliability was high in recreational participants. However, there is a limitation of the Run Rocket in relation to the magnitude of load and corresponding digital representation on the display. It is not clear if the numerical value on the display relates to load, and this limits the ability to apply resistance based on mass. Therefore, this equipment could be used as a tool during sprint efforts where load is determined as a decrement to velocity. This method has been used in a number of studies and has also highlighted the individualised response to load and velocity (Cahill *et al.*, 2019; Cochrane and Monaghan, 2021). Acute and longitudinal studies are required to show its effectiveness to increase performance compared to other methods e.g., sled, downhill sprinting, overspeed training.

Practically, where athletes are required to increase horizontal forces in sprinting movements, the Run Rocket can be used as it has been shown to provide sufficient resistance to decrease sprint velocity. The results of this study show that athletes can be prescribed sprint training based on the magnitude of velocity loss over short distances that are related to distances covered in a range of sporting settings. Finally, the results of this study lead into the effects of resisted sprinting as a preconditioning activity (Study 2).

2.2 Study 2

Godwin, M., Dhone, S., and Newman, M. (2023). Post-activation performance enhancement after resisted sprinting in recreationally active participants: a double-blind randomised crossover trial. *International Journal of Strength and Conditioning*, 3(1).

Study 1 reported the reliability of the Run Rocket over short sprint distances and at two levels of resistance. The purpose of this trial was to study the effects of resisted sprinting as a conditioning activity to evoke postactivation performance enhancement (PAPE) in recreationally active participants. There is limited evidence on the acute effects of resisted sprinting and subsequent performance enhancement. The existing evidence yields inconclusive results with differences in equipment and loading strategies making prescription problematic. Currently, the optimal load for sprinting enhancement has yet to be established (Zabaloy *et al.*, 2023). Percentages of body mass and decrement in velocity have both been used to prescribe loading for a range of athletes. One issue with choosing a load for sled pulling is the interaction between the equipment and the surface. This friction coefficient varies depending on the surface making it difficult to use outdoors where environmental conditions may affect the surface friction. The use of the Run Rocket may alleviate this issue as the resistance is made by applying friction to a flywheel. Therefore, the Run Rocket can be used in environments where surface friction may pose a problem if a traditional sled is used e.g., synthetic track or grass. Dependent on environmental factors, such as moisture, the load prescribed may not indicate the overall effort of the athlete if the friction is reduced. Using equipment that can reliably decrease velocity, loading strategies based on this method can be used.

Two resistance settings were chosen based on the results from Study 1 (RR0 and RR5). The distance of 15 m was chosen to reflect short sprints seen in a variety of team sports which also allows direct comparison to the majority of other studies (Andrzejewski *et al.*, 2015). The primary outcome measure was sprint time for 15 m, with secondary outcomes of velocity and acceleration (5 and 15 m). A double-blind randomised crossover design was used to reduce the risk of bias. The participants were recreationally active (>1 year of structured physical activity) and were recruited from a cohort of university strength and conditioning students. All the participants were familiar with resisted sprinting as a conditioning activity, but none had participated in any structured sprint training that used this equipment. All the testing took place in an indoor performance centre and the sprinting took place on an indoor sprint track.

A limitation to the prescription of resistance on the Run Rocket is the lack of corresponding load. The numerical value on the digital dial display has no known load equivalent and cannot be used to provide a resistance based on kilograms. However, based on Study 1, two resistance settings were chosen and results from the current study showed the two settings elicited a velocity decrement (V_{dec}) of 18.1% ± 5 and 40.4% ± 6.1 (RR0 and RR5, respectively). These values fall in line with other studies that have shown acute sprint performance following sled towing. Furthermore, the velocity at 5 m was within a range that has been used to develop peak power optimally for recreational mixed-sport athletes and sprinters (4.19 ± 0.19 and 4.90 ± 0.18 $m \cdot s^{-1}$).

Similar to Study 1, the ICC for the 5 m sprints was high (.950, 95% CI .868, .984 and .945, 95% CI .853, .983) for RR0 and RR5 respectively. Sprint time, velocity and acceleration for both distances showed no significant differences between groups. However, from a practitioner perspective, several participants did exceed the smallest worthwhile change (SWC) for 5 and 15 m. Over the 5 m distance six participants exceeded the SWC for RR0 and RR5. At 15 m, four participants exceeded the SWC for RR0 and five at RR5 demonstrating the individual variability in response to the conditioning activity.

The revised JBI critical appraisal tool showed limited bias related to selection and allocation as participants were randomly allocated to groups, their treatment was concealed, and groups were similar at baseline (crossover design). The participants and lead researcher did not have sight of the allocation and were therefore blind to the treatment (RR0 or RR5). Other than the differences in load, the participants were all treated the same for both sessions. Bias related to assessment, detection and measurement of the outcome, were accounted for in questions 7, 8 and 9. The lead researcher (outcome assessor) was blind to treatment assignment, and outcomes were measured in a reliable and similar way for both conditions. This concealment may reduce some of the risk of performance bias as the outcome assessor had no knowledge of participant allocation. However, it is acknowledged that the participants may have been able to recognise differences in resistance settings following the familiarisation session. This may have influenced their subsequent performance, but all attempts to conceal this from the participants were made. All participants were accounted for and the results from all 11 participants were analysed appropriately. This lack of attrition bias is seen as positive in a randomised control trial, where losing >5% of the participants may lead to some bias (Schulz and Grimes, 2002). The addition of SWC was used to highlight possible individual variation and heterogeneity within the participants. Overall, the study demonstrated a low risk of bias across all of the 13 questions.

Resisted sprinting is commonplace and is linked to the demands of numerous sports. However, prescribing load remains a debated issue. Acute performance enhancement, via a conditioning activity that may elicit postactivation potentiation is a viable approach for strength and conditioning practitioners. Resisted sprinting is one such mechanism that has shown varying results. Based on the results of this study, the use of the Run Rocket to provide the conditioning activity did not produce an overall increase in performance for a recreationally active population. However, there was variation within the cohort, with some participants exceeding the SWC. Therefore, there is evidence to support individual responses to PAPE using the Run Rocket, when measured by the SWC, that warrant further investigation if this conditioning method is to be used. It is recommended that future studies assess resisted sprinting across a range of populations, not just the cohort of this study. The results from recreationally active participants should not be extrapolated to a wider population.

Assessor: Godwin	**Date of Appraisal:**	**Record Number: N/A**
Study Author: Godwin *et al.*	**Study Title:** Post-activation performance enhancement after resisted sprinting in recreationally active participants.	**Study Year: 2023**

Internal Validity		Choice - Comments/Justification	Yes	No	Unclear	N/A
Bias related to selection and allocation						
1	**Was true randomization used for assignment of participants to treatment groups?**		☒	☐	☐	☐
2	**Was allocation to treatment groups concealed?**		☒	☐	☐	☐
3	**Were treatment groups similar at the baseline?**		☒	☐	☐	☐
Bias related to administration of intervention/exposure						
4	**Were participants blind to treatment assignment?**		☒	☐	☐	☐
5	**Were those delivering the treatment blind to treatment assignment?**		☒	☐	☐	☐
6	**Were treatment groups treated identically other than the intervention of interest?**		☒	☐	☐	☐
Bias related to assessment, detection and measurement of the outcome						
7	**Were outcome assessors blind to treatment assignment?**		**Yes**	**No**	**Unclear**	**N/A**

	Sprint time		☒	☐	☐	☐
	Velocity		☒	☐	☐	☐
	Acceleration		☒	☐	☐	☐

8	**Were outcomes measured in the same way for treatment groups?**		**Yes**	**No**	**Unclear**	**N/A**
	Sprint time		☒	☐	☐	☐
	Velocity		☒	☐	☐	☐
	Acceleration		☒	☐	☐	☐

9	**Were outcomes measured in a reliable way**		**Yes**	**No**	**Unclear**	**N/A**
	Sprint time		☒	☐	☐	☐
	Velocity		☒	☐	☐	☐
	Acceleration		☒	☐	☐	☐

Bias related to participant retention

10	**Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?**		

	Sprint time		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Velocity		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Acceleration		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐

Statistical Conclusion Validity

11	**Were participants analysed in the groups to which they were randomized?**					
	Sprint time		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Velocity		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Acceleration		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐

12	**Was appropriate statistical analysis used?**		

	Sprint time		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Velocity		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Acceleration		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐

			Yes	**No**	**Unclear**	**N/A**
13	**Was the trial design appropriate and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?**		☒	☐	☐	☐

Overall appraisal: **Include:** ☒ **Exclude:** ☐ **Seek Further Info:** ☐

2.3 Study 3

Godwin MS, Fearnett T, Newman MA. (2021). The Potentiating Response to Accentuated Eccentric Loading in Professional Football Players. *Sports*. 2021; 9(12):160.

The aim of this study was to see if an accentuated eccentrically loaded countermovement jump, 20 or 40% body mass, provided a sufficient stimulus to evoke a postactivation performance enhancement (PAPE) compared with a body mass only countermovement jump (CMJ). The primary outcome was jump height, with peak power and peak velocity as secondary outcomes. Peak power was also scaled to body mass. The population in this trial were professional football players, that played in the third tier of the English Football League. There is a noticeable lack of accentuated eccentric loading studies with professional athletes, and in particular, football athletes. The study was conducted during the season (September to November) during which time, the athletes typically underwent approximately 25 hr of training each week, including a match day. The athletes had all taken part in structured strength training (>2 years), had some experience of AEL and were considered well-trained.

The loads chosen were based around a range of studies and were submaximal i.e., less than their 100% concentric maximum (Sheppard *et al.*, 2008; Bridgeman *et al.*, 2017) and is in line with the recommendations from Merrigan *et al*. (2022). The study was undertaken within the season and at their indoor training facility. Participants were randomised into three groups (random.org) and the order of trials was randomised to account for test-order effects. This reduced the likelihood of allocation bias that has been shown to possibly affect the intervention effect estimates (Page *et al.*, 2016). Exaggeration of results has been shown in studies where inadequate or unclear sequence generation is demonstrated (Page *et al.*, 2016).

The additional load was applied by dumbbells equating to either 20 and 40% (AEL20 and AEL40, respectively) of body mass and rounded to the nearest fixed load dumbbell (15.84 ± 1.7 kg and 31.67 ± 3.40 kg, respectively). All testing took place in an indoor training facility at approximately the same time in the evening, following 24 hr of rest (no matches or training session).

Sample size was calculated using the effect sizes from previous studies. Due to the convenience of the population sampled, a total of 27 athletes were initially recruited. Due to injury and 3 incomplete data sets, a total of 23 participants completed the whole trial and were used for data analysis. A repeated-measures design was used to assess differences between the three trials (CON, AEL20 and AEL40). Reliability was assessed by intraclass correlation coefficient (ICC) by way of two-way mixed effects model. The magnitude of effects was given using generalised eta squared for within subjects difference and Bonferroni correction was used for post hoc analysis if a significant difference was found.

The results showed no difference for the primary outcome (jump height). There was a significant difference in peak power for both AEL conditions compared to the control (CON 2444.9 ± 680.34 W, AEL20 2974.18 ± 725.89 W, AEL40 3202.44 ± 861.99 W; F (2.44), $p = 0.001$, $\eta 2G = 0.154$). No difference was seen for peak velocity.

Based on the revised JBI critical appraisal tool, two questions were scored as ‘no’ and one ‘unclear’ (4, 5 and 2, respectively). Relating to internal validity, the participants were concealed to the allocation of intervention, but this was not reported in the publication. Participants were not blinded to the interventions as they were required to hold a dumbbell in each hand for the two AEL conditions and for the control, they placed their hands by their sides. The participants were not informed of the mass of the dumbbells, nor did they know the order in which they would be undertaking the trials as this was randomised by the researcher and concealed to the participants. This inability to conceal the intervention or control may led to bias. However, the researcher taking the data did not reveal the conditions to the lead researcher until after the data was analysed. Columns of data were coded to limit the risk of influencing the data analysis.

There was no bias relating to participant retention. All participants were accounted for, including those that did not complete all the trials. Statistical conclusion validity was clear on the publication as all participants were analysed in the groups to which they were randomized. Overall, there was no outcome reporting bias as the primary and secondary outcomes were reported and analysed based on the *a priori* classifications (primary - jump height; secondary – peak velocity and peak power).

Accentuated eccentric loading is used to provide a greater eccentric load than the concentric component of an activity requiring both eccentric and concentric actions e.g., squat, countermovement jump. AEL can be implemented via several methods, including weight-releasers, elastic bands and manual application such as dumbbells. Based on the results of this study, AEL may provide enough stimulus to increase peak power at two loads (20 and 40% body mass). However, there was no difference in vertical jump performance. Therefore, if the targeted outcome was peak power, this method may be used by professional football players during their in-season. The study was conducted during the season and there was no way to control for the effects of training and matches, apart from the 24 hr rest period prior to testing. This is acknowledged as a limitation of this study. However, it is the first known study that has looked at the acute effects of AEL on professional footballers during the in-season and does have practical application. The AEL condition did not appear to have a negative effect on jump performance and it may be considered for longer training periods, not just as an acute preconditioning activity. The addition of this load may need to be accounted for in the overall training load of each athlete.

Assessor: Godwin	**Date of Appraisal:**	**Record Number: N/A**
Study Author: Godwin *et al.*	**Study Title:** The Potentiating Response to Accentuated Eccentric Loading in Professional Football Players	**Study Year: 2021**

Internal Validity		**Choice - Comments/Justification**	**Yes**	**No**	**Unclear**	**N/A**
Bias related to selection and allocation						
1	**Was true randomization used for assignment of participants to treatment groups?**		☒	☐	☐	☐
2	**Was allocation to treatment groups concealed?**	Participants were not aware of the groups they were in. Not reported in publication.	☐	☐	☒	☐
3	**Were treatment groups similar at the baseline?**		☒	☐	☐	☐
Bias related to administration of intervention/exposure						
4	**Were participants blind to treatment assignment?**	Participants could not be blind to interventions. However, they did not know the order of intervention.	☐	☒	☐	☐
5	**Were those delivering the treatment blind to treatment assignment?**	Researchers had to choose the dumbbells and were therefore not blind to assignment.	☐	☒	☐	☐
6	**Were treatment groups treated identically other than the intervention of interest?**		☒	☐	☐	☐
Bias related to assessment, detection and measurement of the outcome						

7	Were outcome assessors blind to treatment assignment?		Yes	No	Unclear	N/A
	Jump height		☒	☐	☐	☐
	Peak power		☒	☐	☐	☐
	Peak velocity		☒	☐	☐	☐

8	Were outcomes measured in the same way for treatment groups?		Yes	No	Unclear	N/A
	Jump height		☒	☐	☐	☐
	Peak power		☒	☐	☐	☐
	Peak velocity		☒	☐	☐	☐

9	Were outcomes measured in a reliable way		Yes	No	Unclear	N/A
	Jump height		☒	☐	☐	☐
	Peak power		☒	☐	☐	☐
	Peak velocity		☒	☐	☐	☐

Bias related to participant retention

10	**Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?**					
	Jump height		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Peak power		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Peak velocity		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐

Statistical Conclusion Validity

11	**Were participants analysed in the groups to which they were randomized?**					
	Jump height		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Peak power		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Peak velocity		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐

12	**Was appropriate statistical analysis used?**					
	Jump height		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Peak power		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Peak velocity		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐

			Yes	**No**	**Unclear**	**N/A**
13	**Was the trial design appropriate and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?**		☒	☐	☐	☐

Overall appraisal: **Include:** ☒ **Exclude:** ☐ **Seek Further Info:** ☐

2.4 Study 4

Godwin, M., Stanhope, E., Bateman, J., & Mills, H. (2020). An Acute Bout of Self-Myofascial Release Does Not Affect Drop Jump Performance despite an Increase in Ankle Range of Motion. *Sports*, *8*(3), 3

The aim of this was study was to compare the performance of the drop jump following a warmup that included an additional bout of self-myofascial release, and a warmup only group. Ankle range of motion was assessed following the warmup. Using a standardised protocol that included self-myofascial release on five regions of the body: (1) thoracic/lumbar, (2) gluteals, (3) hamstrings, (4) triceps surae and (5) quadriceps/flexors, the intervention was administered using a commercially available foam roller (GRID® foam roller, Implus LLC, USA). Starting at the muscle origin, five strokes per 30 s were applied bilaterally until the muscle insertion. Active dorsiflexion of the dominant foot was assessed using the weight-bearing lunge test. Drop jump performance was assessed using force plates (Force Decks FD4000, UK) and participants performed the jumps from a 30 cm box. Outcome measures from the drop jump were jump height (flight time method), lower limb stiffness (the change in vertical force divided by the displacement of the CMJ during the eccentric phase), reactive strength index (jump height divided by flight time) and modified reactive strength index (flight time divided by the time to take off). In addition to the range of motion and drop jump measures, an isokinetic dynamometer (Humac Norm, CSMi Solutions, USA) was used to assess the concurrent validity of a smartphone digital inclinometer app (Clinometer app, Plain Code, Germany).

The inclusion of a standardised warm up as part of the protocol was to increase the ecological validity of the study. Warneke and colleagues reported that studies have compared foam rolling to a control condition, but not to active exercise (Warneke *et al.*, 2023). Therefore, this study aimed to bridge this gap by including a warmup that had been used in a previous foam rolling study and would be commonplace in a sporting context (Healey *et al.*, 2014) and included: (1) walking lunges; (2) walking knee to chest; (3) side squats; (4) walking butt kicks; (5) frankensteins; and, (6) penny pickers. Drop jumps were chosen as they have been used in a range of plyometric studies to increase performance across a range of outcome measures

(Chen *et al.*, 2013; De Poli *et al.*, 2020; A. M. Zagatto *et al.*, 2022; A. Zagatto *et al.*, 2022). Participants were randomly assigned to either warmup plus foam rolling or warm up only using block randomisation (block size of 4) which was undertaken by an independent researcher and concealed to the rest of the research group. This approach is used to prevent any imbalances when allocating participants to treatments (Burger, Vaudel and Barsnes, 2021).

Results showed no differences in performance between the groups for all outcomes. There was a significant difference in range of motion as measured by the weight-bearing lunge test ($F = 22.9$, $p < 0.001$, $\eta^2 = 0.024$). However, no differences were found between the foam rolling group and the control group. For the foam rolling group, the effect size was $d = 0.4$, and in the control group the effect size was $d = 0.6$.

Based on the JBI critical appraisal tool there was a low risk of bias relating to the selection and allocation of participants to the treatments as randomisation was used. This was initially concealed to the researchers and was not shared during the trial. Separate staff conducted the warmup and foam rolling away from the sight of the remaining researchers. Participants were initially blinded to treatment allocation, but there was no way to perform foam rolling without their knowledge. All participants were treated in the same way apart from the intervention. The researchers assessing the weight-bearing lunge test and the drop jump assessment were not informed of the group allocation, although this was not explicit in the publication and was scored as unclear in the critical appraisal. The outcomes were measured using valid methods and in a reliable way. Reliability assessed during the trial showed that the Clinometer App was very high compared to the isokinetic dynamometer ($r = 0.99$, standardised typical error = 0.02, 95% CI = 0.01, 0.02). Reliability of the drop jump was also very high ($r = 0.94$, 95% CI = 0.88, 0.97). Participant retention was reported, with 25 of the 30 completing the study (male = 16, female = 9). All outcomes decided *a priori* were analysed and presented in the paper, thereby reducing any outcome reporting bias.

Overall, there was no supporting evidence that foam rolling contributed to drop jump performance in this population compared to a standardised warm up. However, foam rolling did contribute to an increase in range of movement at the ankle when assessed with the weight-bearing lunge test. When compared to a standardised warm up, there was no difference in range of movement between the two conditions. Therefore, it was concluded that the inclusion of foam rolling during a standardised warm up had no additional benefits to warm up alone and does not produce any acute performance enhancement in this population.

Assessor: Godwin	**Date of Appraisal:**	**Record Number:**
Study Author: Godwin *et al*.	**Study Title:** An Acute Bout of Self-Myofascial Release Does Not Affect Drop Jump Performan despite an Increase in Ankle Range of Motion	**Study Year:**

Internal Validity		Choice - Comments/Justification	Yes	No	Unclear	N/A
Bias related to selection and allocation						
1	**Was true randomization used for assignment of participants to treatment groups?**		☒	☐	☐	☐
2	**Was allocation to treatment groups concealed?**		☒	☐	☐	☐
3	**Were treatment groups similar at the baseline?**		☒	☐	☐	☐
Bias related to administration of intervention/exposure						
4	**Were participants blind to treatment assignment?**		☐	☒	☐	☐
5	**Were those delivering the treatment blind to treatment assignment?**		☐	☒	☐	☐
6	**Were treatment groups treated identically other than the intervention of interest?**		☒	☐	☐	☐
Bias related to assessment, detection and measurement of the outcome						
7	**Were outcome assessors blind to treatment assignment?**		Yes	No	Unclear	N/A

	Weight-bearing lunge test		☐	☐	☒	☐
	Vertical jump		☐	☐	☒	☐
	RSI		☐	☐	☒	☐
	RSI mod		☐	☐	☒	☐
	Stiffness		☐	☐	☒	☐

8	**Were outcomes measured in the same way for treatment groups?**		**Yes**	**No**	**Unclear**	**N/A**
	Weight-bearing lunge test		☒	☐	☐	☐
	Vertical jump		☒	☐	☐	☐
	RSI		☒	☐	☐	☐
	RSI mod		☒	☐	☐	☐
	Stiffness		☒	☐	☐	☐

9	**Were outcomes measured in a reliable way**		**Yes**	**No**	**Unclear**	**N/A**
	Weight-bearing lunge test		☒	☐	☐	☐
	Vertical jump		☒	☐	☐	☐

	RSI		☒	☐	☐	☐
	RSI mod		☒	☐	☐	☐
	Stiffness		☒	☐	☐	☐

Bias related to participant retention

10	**Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?**					
	Weight-bearing lunge test		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Vertical jump		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	RSI		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	RSI mod		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Stiffness		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐

Statistical Conclusion Validity

11	**Were participants analysed in the groups to which they were randomized?**					
	Weight-bearing lunge test		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Vertical jump		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	RSI		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	RSI mod		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Stiffness		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐

12	**Was appropriate statistical analysis used?**					
	Weight-bearing lunge test		**Yes**	**No**	**Unclear**	**N/A**

	Result 1		☒	☐	☐	☐
	Vertical jump		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	RSI		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	RSI mod		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐
	Stiffness		**Yes**	**No**	**Unclear**	**N/A**
	Result 1		☒	☐	☐	☐

			Yes	**No**	**Unclear**	**N/A**
13	**Was the trial design appropriate and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?**		☒	☐	☐	☐

Overall appraisal: **Include:** ☒ **Exclude:** ☐ **Seek Further Info:** ☐

3.0 New knowledge and practical application to athletic performance

Acute performance enhancement can be a goal of a particular training session or a specific event. Novel stimuli are sought by practitioners to increase performance and this body of research has highlighted some issues relating to exercise prescription and equipment use. Based on this body of research, preconditioning activities may be useful to acutely enhance performance, but there appears to be a degree of individual variation. Furthermore, when combined with a thorough warm up, some activities do not appear to enhance performance when compared to warm up alone (self-myofascial release). Numerous factors may impact PAPE, including the relative strength of the athlete and timing of activity, that need to be considered when adopting these types of activities.

Study 1 - Intra and intersession reliability of the Run RocketTM in recreationally trained participants

Firstly, there was no known published reliability trial of the Run Rocket. Considering the importance of sprinting in sport and the methods used to enhance performance, there was a need to provide evidence of reliability. In football for example, elite female players have been shown to cover between 122 and 615 m of sprinting during a game (Mara *et al.*, 2017; Scott, Norris and Lovell, 2020). In the English Premiership, male footballers cover 295 m sprinting and between 620 and 706 m of high speed running (Anderson *et al.*, 2016; Kelly *et al.*, 2020). Analysis of teams sports has shown that distances less than 30 m are typical and last for short periods (2-3 s) (Murphy *et al.*, 2023). The Run Rocket equipment is used by a range of athletes to provide resistance during sprinting activities. It may have the benefit over other methods, such as sled towing, as the coefficient of friction does not play a role in the chosen surface where the activity is performed. From a practical standpoint, the equipment can be used on a range of surfaces that may be suitable for the type of athlete e.g., grass or sprint track. The only consideration is the load or the ability to reduce the velocity by a required amount (%V_{dec}). The results from Study 1 provide practitioners with the data to support the use of this equipment with recreationally active participants. A high degree of reliability may make this equipment suitable for acute interventions or long-term training blocks, based on any principles of periodisation. The two chosen resistance settings in this study were based on previous use of the equipment and fell within a range used in other studies. Future research should aim to study different loading strategies and different participants as there is a wide range of heterogeneity between athletes and recreationally active participants.

Study 2 - Post-activation performance enhancement after resisted sprinting in recreationally active participants: a double-blind randomised crossover trial

Sprinting and high speed running is key in sports such as football (Anderson *et al.*, 2016; Carling *et al.*, 2016; Modric *et al.*, 2019; Kelly *et al.*, 2020). The subsequent study, published in the International Journal of Strength and Conditioning highlighted that recreationally active individuals may not achieve any acute performance enhancement when using resisted sprinting as a stimulus. This knowledge contributes to a body of knowledge relating to PAPE and its application with recreationally active participants. One of the drivers behind the use of resisted sprinting prior to sprint performance is the notion of dynamic correspondence. Brearley and Bishop (2019) note that it is not possible to fully meet the criteria of dynamic correspondence for all activities and that conditioning activities are acceptable if they meet some of the criteria. However, in resisted sprinting, the activity does meet several the criteria (amplitude and direction of movement; accentuated region of force development; dynamics of the effort; regime of muscular work). The final criteria that resisted sprinting may not achieve is the rate and time of maximal force production. Ground contact time is the application of force as the foot strikes the surface and occurs in a short period of time during sprinting. It is critical to sprint performance as it is the only interaction between the sprinter and the application of force (Kratky and Müller, 2013; Mattes, Wolff and Alizadeh, 2021). A greater sprint performance has been shown to be related to short contact times and in elite sprinting, a shorter ground contact time is correlated with significantly higher sprint speed (Kratky and Müller, 2013; Mattes, Wolff and Alizadeh, 2021). Therefore, one aim of a conditioning programme may be to maximise force production over a short period of time, by minimising ground contact time. When resisted sprinting is used, it may impact the ability to reduce contact time. Zabaloy *et al.* (2022) showed that ground contact time was significantly impacted during loaded sled pulls with amateur rugby players. Using velocity decrements of 10, 30 and 50%, significant increases in contact time were reported (9.9, 31.3 and 53.5%, respectively). This is due to the slowing down of the movement due to the additional load. However, this may be minimal in some loading strategies (Petrakos, Egan and Morin, 2016). For example, when using a body weight supported kite, ground contact time can be reduced over 20 m sprints in elite male sprinters (Kratky and Müller, 2013). This study did not record ground contact time and may be seen as a limitation in assessing this kinematic variable.

Using the smallest worthwhile change in addition to null hypothesis significance testing, the results showed variation between participants. Practically, this showed that participants may respond differently to conditioning activities and that individualised programming is recommended. This includes the optimal load to induce an acute performance and the balance between potentiation and fatigue. A hypothetical relationship between a conditioning contraction and performance has been proposed (Tillin and Bishop, 2009). This relationship shows that potentiation is high or more dominant when the condition volume is low. Conversely, fatigue becomes more dominant as the conditioning volume increases, negatively impacting performance (Tillin and Bishop, 2009). The Run Rocket is able to provide sufficient resistance to reduce velocity, that can be used to prescribe a percentage of velocity decrement.

Study 3 - The Potentiating Response to Accentuated Eccentric Loading in Professional Football Players

In professional football, the vertical jump has been shown to be used as an assessment of the required skills of kicking at maximal speed (Rodríguez-Lorenzo *et al.*, 2016). Moderate to strong correlations exist between countermovement jump performance, 30 m sprint and change of direction in female collegiate football players (McFarland *et al.*, 2016). In the same study, moderate correlations have been shown in male collegiate football players for 10 and 30 m sprint tests (McFarland *et al.*, 2016). The AEL study has had over 2100 views and contributes to the limited knowledge of the effect of PAPE with professional athletes. Most studies of AEL has used recreationally active individuals or strength-trained participants.

Considering the importance of rate of force development in field-based team sports, and the recommendation to study AEL within an athletic population, the results of this study support this. Jump performance, often referred to as explosive strength, is linked to football performance and is commonly used to assess fitness and talent selection (Castagna and Castellini, 2013). The link between jump performance and football performance have been identified, making this a key performance target in football conditioning programmes. Ramirez-Campillo *et al.* 2020) reported that the vertical jump is one to two most frequent actions prior to scoring, has a significant correlation to final team performance in a league and is superior to that of non-elite players. Therefore, any method to enhance jump performance, chronically or acutely, appears to be justifiable. Plyometric training is a common method to increase jump performance in football players and is subsequently recommended as a conditioning practice (Slimani, Paravlić and Bragazzi, 2017). AEL uses the stretch shortening cycle, with an additional load added during the eccentric phase in an attempt to increase concentric velocity (Taber *et al.*, 2021). The effects of AEL are inconclusive and lower limb modelling has been used to simulate the effects of AEL on countermovement jump performance (Su *et al.*, 2023). This simple modelling showed no differences in jump height between AEL and non-AEL conditions. Practically, there are considerations of this type of preconditioning activity. As the athlete moves towards the floor during the eccentric phase, the additional mass means that the negative vertical impulse is larger in the AEL conditions, compared to non-AEL. A greater positive vertical impulse is therefore required to decelerate the additional load (Su *et al.,* 2023).

There may be a trade-off between the potentiating effects of AEL and fatigue that may impair subsequent performance (Bridgeman *et al.*, 2017). In weaker athletes, this may be a limiting factor. The athletes used in the study were professional football players, from the third tier of the English Football League, and were strength trained (*n*= 23). Despite this, there was no differences in jump height for the three conditions, using loads in the range of other studies. Peak power was shown to be greater for the two AEL conditions compared to body mass only. Therefore, based on this study with professional football players, no evidence was shown to support AEL to acutely enhance vertical jump performance.

Study 4 - An Acute Bout of Self-Myofascial Release Does Not Affect Drop Jump Performance despite an Increase in Ankle Range of Motion

The final study contributed to the body of literature that does not show performance benefits of foam rolling when used with a suitable warm up strategy. Similar to the previous study, jump performance plays a role in team sports, such as football and basketball (Castagna and Castellini, 2013; Pehar *et al.*, 2017; Ramirez-Campillo *et al.*, 2020). Despite the popularity of foam rolling, results from this study only showed that ankle range of motion (knee to wall test) was increased following a bout of self-myofascial release. However, there was no difference observed between the warmup group and the foam rolling group. This is in line with a recent systematic review and meta-analysis that looked at foam rolling and stretching on physical performance (Konrad, Tilp and Nakamura, 2021). The overall effect of foam rolling (pre to post or post to control) was 2.19%, compared to 1.11% increase following a single bout of static stretching. In a comparative study, Behara and Jacobson (2017) reported no differences in performance variables (peak power, mean power, peak velocity or mean velocity) following the foam rolling intervention. Similarly, Grabow *et al.* (2018) showed that a bout of roller massage increases range of movement, but has no significant effect on drop jump performance. Practically, foam rolling appears to be non-detrimental to acute performance across a range of participants and outcome measures.

This article was cited by Wang and colleagues who compared the results to their findings of a vibration foam rolling on athletic performance in tennis players (Wang *et al.*, 2022). However, their study only incorporated 5 min of jogging as the warmup at a self-selected pace. This article has also been cited 9 times in international, peer reviewed journals.

3.1 Implications for future research

The reliability of the Run Rocket opens the opportunity to investigate how this equipment could be used in a strength and conditioning setting. For example, the comparison between other methods of sprint training and this type of resisted sprint training for acute and longitudinal studies. Furthermore, as demonstrated in Study 2, there is scope to develop this methodology to investigate different loads and PAPE responses. One major implication across the studies has been the individual responses to conditioning activities. To mitigate these responses, the use of the smallest worthwhile change (SWC) is recommended. In addition to the use of statistical tests, confidence intervals and effect sizes, the SWC may help to contextualise the physiological meaning of the intervention across a range of participants (Marocolo *et al.*, 2019). However, it is acknowledged that there is a lack of consensus around the use of SWC and by what factor the between-subject standard deviation is multiplied. Marocolo *et al.* (2019) suggests that multiplying by 0.2 is suitable for participants with a high level of fitness, whereas 0.6 could be used for both high and low level participants. There is evidence from this body of literature to support this heterogeneity, and this has been linked to a number of factors, including strength levels and the balance between the conditioning activity and fatigue. If acute performance enhancement is to be used, then it should be prescribed by an individual response basis. The type or conditioning activity may also play a role in the effectiveness of this training method.

3.2 Conclusion

This body of work contributes to the field of applied exercise science in that acute performance enhancement is not straightforward. In fact, the type of conditioning activities and the timing of them play an important role in them being effective, with the results being highly individualised. The first study showed that novel resisted sprint equipment is highly reliable over short distances, those seen in team sports. The use of this equipment in the second study did not elicit a performance enhancement for recreationally active participants. However, further studies need to identify best practice for the use of resisted sprinting as a conditioning activity. Studies 3 and 4 may have cast doubt over whether foam rolling or accentuated eccentric loading can contribute to acute performance enhancement, despite the popularity of use. However, the latter may provide some stimulus for power development.

References

Aboodarda, S.J. *et al.* (2013) ‘Enhanced Performance With Elastic Resistance During the Eccentric Phase of a Countermovement Jump’, *International Journal of Sports Physiology and Performance*, 8(2), pp. 181–187. Available at: https://doi.org/10.1123/ijspp.8.2.181.

Aboodarda, S.J. *et al.* (2014) ‘Does Performing Drop Jumps With Additional Eccentric Loading Improve Jump Performance?’, *Journal of Strength and Conditioning Research*, 28(8), pp. 2314–2323. Available at: https://doi.org/10.1519/JSC.0000000000000498.

Ajimsha,M, Al-Mudahka, Noora and Al-Madzha, J (2015) ‘Effectiveness of myofascial release: Systematic review of randomized controlled trials’, *Journal of Bodywork and Movement Therapies*, 19, pp. 102–112. Available at: https://doi.org/10.1016/j.jbmt.2014.06.001.

Alonso-Fernandez, D., Docampo-Blanco, P. and Martinez-Fernandez, J. (2018) ‘Changes in muscle architecture of biceps femoris induced by eccentric strength training with nordic hamstring exercise’, *Scandinavian Journal of Medicine & Science in Sports*, 28(1), pp. 88–94. Available at: https://doi.org/10.1111/sms.12877.

Anderson, L. *et al.* (2016) ‘Quantification of training load during one-, two- and three-game week schedules in professional soccer players from the English Premier League: implications for carbohydrate periodisation’, *Journal of Sports Sciences*, 34(13), pp. 1250–1259. Available at: https://doi.org/10.1080/02640414.2015.1106574.

Andrzejewski, M. *et al.* (2015) ‘Sprinting Activities and Distance Covered by Top Level Europa League Soccer Players’, *International Journal of Sports Science & Coaching*, 10(1), pp. 39–50. Available at: https://doi.org/10.1260/1747-9541.10.1.39.

Askling, C., Karlsson, J. and Thorstensson, A. (2003) ‘Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload: Hamstring training in soccer players’, *Scandinavian Journal of Medicine & Science in Sports*, 13(4), pp. 244–250. Available at: https://doi.org/10.1034/j.1600-0838.2003.00312.x.

Barker, T.H. *et al.* (2023) ‘The revised JBI critical appraisal tool for the assessment of risk of bias for randomized controlled trials’, *JBI Evidence Synthesis*, 21(3), pp. 494–506. Available at: https://doi.org/10.11124/JBIES-22-00430.

Baudry, S. and Duchateau, J. (2007) ‘Postactivation potentiation in a human muscle: effect on the load-velocity relation of tetanic and voluntary shortening contractions.’, *Journal of Applied Physiology*, 103(4), pp. 1318–1325.

Beardsley, C. and Škarabot, J. (2015) ‘Effects of self-myofascial release: A systematic review’, *Journal of Bodywork and Movement Therapies*, 19(4), pp. 747–758. Available at: https://doi.org/10.1016/j.jbmt.2015.08.007.

Beato, M. (2022) ‘Recommendations for the design of randomized controlled trials in strength and conditioning. Common design and data interpretation’, *Frontiers in*

Sports and Active Living, 4, p. 981836. Available at: https://doi.org/10.3389/fspor.2022.981836.

Behara, B. and Jacobson, B.H. (2017) ‘Acute effects of deep tissue foam rolling and dynamic stretching on muscular strength, power, and flexibility in Division I linemen’, *Journal of Strength and Conditioning Research*, 31(4), pp. 888–892.

Berthelot, G. *et al.* (2015) ‘Has Athletic Performance Reached its Peak?’, *Sports Medicine*, 45(9), pp. 1263–1271. Available at: https://doi.org/10.1007/s40279-015-0347-2.

Bialocerkowski, A., Klupp, N. and Bragge, P. (2010) ‘How to read and critically appraise a reliability article’, *International Journal of Therapy and Rehabilitation*, 17(3), pp. 114–120. Available at: https://doi.org/10.12968/ijtr.2010.17.3.46743.

Blazevich, A.J. and Babault, N. (2019) ‘Post-activation Potentiation Versus Post-activation Performance Enhancement in Humans: Historical Perspective, Underlying Mechanisms, and Current Issues’, *Frontiers in Physiology*, 10, p. 1359. Available at: https://doi.org/10.3389/fphys.2019.01359.

Bradshaw, E. *et al.* (2010) ‘Reliability and variability of day-to-day vault training measures in artistic gymnastics’, *Sports Biomechanics*, 9(2), pp. 79–97. Available at: https://doi.org/10.1080/14763141.2010.488298.

Brandenburg, J.P. and Docherty, D. (2002) ‘The effects of accentuated eccentric loading on strength, muscle hypertrophy, and neural adaptations in trained individuals’, *Journal of Strength and Conditioning Research*, 16(1), pp. 25–32.

Brearley, S. and Bishop, C. (2019) ‘Transfer of Training: How Specific Should We Be?’, *Strength & Conditioning Journal*, 41(3), pp. 97–109. Available at: https://doi.org/10.1519/SSC.0000000000000450.

Bridgeman, L.A. *et al.* (2016) ‘Test-Retest Reliability of a Novel Isokinetic Squat Device With Strength-Trained Athletes’, *Journal of Strength and Conditioning Research*, 30(11), pp. 3261–3265. Available at: https://doi.org/10.1519/JSC.0000000000001410.

Bridgeman, L.A. *et al.* (2017a) ‘The Effects of Accentuated Eccentric Loading on the Drop Jump Exercise and the Subsequent Postactivation Potentiation Response’, *Journal of Strength and Conditioning Research*, 31(6), pp. 1620–1626. Available at: https://doi.org/10.1519/JSC.0000000000001630.

Bridgeman, L.A. *et al.* (2017b) ‘The Effects of Accentuated Eccentric Loading on the Drop Jump Exercise and the Subsequent Postactivation Potentiation Response’, *Journal of Strength and Conditioning Research*, 31(6), pp. 1620–1626. Available at: https://doi.org/10.1519/JSC.0000000000001630.

Brown, I.E. and Loeb, G.E. (1999) ‘Measured and modeled properties of mammalian skeletal muscle. I. The effects of post-activation potentiation on the time course and velocity dependencies of force production’, *Journal of Muscle Research and Cell Motility*, 20(5/6), pp. 443–456. Available at: https://doi.org/10.1023/A:1005590901220.

Buchheit, M. (2018) ‘Magnitudes matter more than Beetroot Juice’, *Sports Performance and Science Reports*, 15, pp. 1–3.

Buonsenso, A. *et al.* (2023) ‘A Systematic Review of Flywheel Training Effectiveness and Application on Sport Specific Performances’, *Sports*, 11(4), p. 76. Available at: https://doi.org/10.3390/sports11040076.

Burger, B., Vaudel, M. and Barsnes, H. (2021) ‘Importance of Block Randomization When Designing Proteomics Experiments’, *Journal of Proteome Research*, 20(1), pp. 122–128. Available at: https://doi.org/10.1021/acs.jproteome.0c00536.

Burns, P.B., Rohrich, R.J. and Chung, K.C. (2011) ‘The levels of evidence and their role in evidence-based medicine’, *Plastic and Reconstructive Surgery*, 128(1), pp. 305–310. Available at: https://doi.org/10.1097/PRS.0b013e318219c171.

Bushell, J.E., Dawson, S.M. and Webster, M.M. (2015) ‘Clinical Relevance of Foam Rolling on Hip Extension Angle in a Functional Lunge Position’, *Journal of Strength and Conditioning Research*, 29(9), pp. 2397–2403. Available at: https://doi.org/10.1519/JSC.0000000000000888.

Cahill, M.J. *et al.* (2019) ‘Sled-Pull Load–Velocity Profiling and Implications for Sprint Training Prescription in Young Male Athletes.’, *Sports (2075-4663)*, 7(5), p. 119.

Carling, C. *et al.* (2016) ‘Match-to-match variability in high-speed running activity in a professional soccer team’, *Journal of Sports Sciences*, 34(24), pp. 2215–2223. Available at: https://doi.org/10.1080/02640414.2016.1176228.

Castagna, C. and Castellini, E. (2013) ‘Vertical Jump Performance in Italian Male and Female National Team Soccer Players’, *Journal of Strength and Conditioning Research*, 27(4), pp. 1156–1161. Available at: https://doi.org/10.1519/JSC.0b013e3182610999.

Cavanaugh, M.T. *et al.* (2017) ‘An acute session of roller massage prolongs voluntary torque development and diminishes evoked pain’, *European Journal of Applied Physiology*, 117(1), pp. 109–117. Available at: https://doi.org/10.1007/s00421-016-3503-y.

CEBM (2009) ‘Oxford Centre for Evidence-Based Medicine: Levels of Evidence (March 2009)’. CEBM. Available at: https://www.cebm.ox.ac.uk/resources/levels-of-evidence/oxford-centre-for-evidence-based-medicine-levels-of-evidence-march-2009.

Cheatham, S.W. and Stull, K.R. (2018) ‘Comparison of a foam rolling session with active joint motion and without joint motion: A randomized controlled trial’, *Journal of Bodywork and Movement Therapies*, 22(3), pp. 707–712. Available at: https://doi.org/10.1016/j.jbmt.2018.01.011.

Chen, Z.-R. *et al.* (2013) ‘The Acute Effect of Drop Jump Protocols With Different Volumes and Recovery Time on Countermovement Jump Performance’, *Journal of Strength and Conditioning Research*, 27(1), pp. 154–158. Available at: https://doi.org/10.1519/JSC.0b013e3182518407.

Cochrane, D.J. and Monaghan, D. (2021) ‘Using Sprint Velocity Decrement to Enhance Acute Sprint Performance.’, *Journal of Strength & Conditioning Research*, 35(2), pp. 442–448.

Coratella, G. *et al.* (2019) ‘Effects of in-season enhanced negative work-based vs traditional weight training on change of direction and hamstrings-to-quadriceps ratio in soccer players’, *Biology of Sport*, 36(3), pp. 241–248. Available at: https://doi.org/10.5114/biolsport.2019.87045.

Currell, K. and Jeukendrup, A.E. (2008) ‘Validity, Reliability and Sensitivity of Measures of Sporting Performance’:, *Sports Medicine*, 38(4), pp. 297–316. Available at: https://doi.org/10.2165/00007256-200838040-00003.

De Hoyo, M. *et al.* (2015) ‘Effects of a 10-Week In-Season Eccentric-Overload Training Program on Muscle-Injury Prevention and Performance in Junior Elite Soccer Players’, *International Journal of Sports Physiology and Performance*, 10(1), pp. 46–52. Available at: https://doi.org/10.1123/ijspp.2013-0547.

De Poli, R.A.B. *et al.* (2020) ‘Cycling Performance Enhancement After Drop Jumps May Be Attributed to Postactivation Potentiation and Increased Anaerobic Capacity’, *Journal of Strength and Conditioning Research*, 34(9), pp. 2465–2475. Available at: https://doi.org/10.1519/JSC.0000000000003399.

Devereaux, P.J. and Yusuf, S. (2003) ‘The evolution of the randomized controlled trial and its role in evidence-based decision making’, *Journal of Internal Medicine*, 254(2), pp. 105–113. Available at: https://doi.org/10.1046/j.1365-2796.2003.01201.x.

Doan, B.K. *et al.* (2002) ‘Effects of increased eccentric loading on bench press 1RM’, *Journal of Strength and Conditioning Research*, 16(1), pp. 9–13.

Dobbs, W.C. *et al.* (2019) ‘Effect of Postactivation Potentiation on Explosive Vertical Jump: A Systematic Review and Meta-Analysis’, *Journal of Strength and Conditioning Research*, 33(7), pp. 2009–2018. Available at: https://doi.org/10.1519/JSC.0000000000002750.

Douglas, J. *et al.* (2017) ‘Chronic Adaptations to Eccentric Training: A Systematic Review’, *Sports Medicine*, 47(5), pp. 917–941. Available at: https://doi.org/10.1007/s40279-016-0628-4.

Fiorilli, G. *et al.* (2020) ‘Isoinertial Eccentric-Overload Training in Young Soccer Players: Effects on Strength, Sprint, Change of Direction, Agility and Soccer Shooting Precision’, *Journal of Sports Science & Medicine*, 19(1), pp. 213–223.

Freiwald, J. *et al.* (2016) ‘Foam-rolling in sport and therapy – Potential benefits and risks’, *Sports Orthopaedics and Traumatology*, 32(3), pp. 258–266. Available at: https://doi.org/10.1016/j.orthtr.2016.07.001.

González-Ravé, J.M. *et al.* (2022) ‘Reverse Periodization for Improving Sports Performance: A Systematic Review’, *Sports Medicine - Open*, 8(1), p. 56. Available at: https://doi.org/10.1186/s40798-022-00445-8.

Grabow, L. *et al.* (2018) ‘Higher quadriceps roller massage forces do not amplify range-of-motion increases nor impair strength and jump performance’, *Journal of Strength and Conditioning Research*, 32(11), pp. 3059–3069. Available at: https://doi.org/10.1519/JSC.0000000000001906.

Griefahn, A. *et al.* (2017) ‘Do exercises with the Foam Roller have a short-term impact on the thoracolumbar fascia? – A randomized controlled trial’, *Journal of Bodywork and Movement Therapies*, 21(1), pp. 186–193. Available at: https://doi.org/10.1016/j.jbmt.2016.05.011.

Guest, N.S. *et al.* (2021) ‘International society of sports nutrition position stand: caffeine and exercise performance’, *Journal of the International Society of Sports Nutrition*, 18(1), p. 1. Available at: https://doi.org/10.1186/s12970-020-00383-4.

Hamada, T., Sale, D.G. and MacDougall, J.D. (2000) ‘Postactivation potentiation in endurance-trained male athletes. / Potentialisation post-activation chez des athletes masculins entraines en endurance.’, *Medicine & Science in Sports & Exercise*, 32(2), pp. 403–411.

Hartmann, H. *et al.* (2015) ‘Short-term Periodization Models: Effects on Strength and Speed-strength Performance’, *Sports Medicine*, 45(10), pp. 1373–1386. Available at: https://doi.org/10.1007/s40279-015-0355-2.

Heale, R. and Twycross, A. (2015) ‘Validity and reliability in quantitative studies’, *Evidence Based Nursing*, 18(3), pp. 66–67. Available at: https://doi.org/10.1136/eb-2015-102129.

Healey, K.C. *et al.* (2014) ‘The effects of myofascial release with foam rolling on performance’, *Journal of Strength and Conditioning Research*, 28(1), pp. 61–68. Available at: https://doi.org/10.1519/JSC.0b013e3182956569.

Hodgson, M., Docherty, D. and Robbins, D. (2005) ‘Post-Activation Potentiation: Underlying Physiology and Implications for Motor Performance’, *Sports Medicine*, 35(7), pp. 585–595. Available at: https://doi.org/10.2165/00007256-200535070-00004.

Hopkins, W.G. (2000) ‘Measures of Reliability in Sports Medicine and Science’:, *Sports Medicine*, 30(1), pp. 1–15. Available at: https://doi.org/10.2165/00007256-200030010-00001.

Hopkins, Will (2002) ‘A Scale of Magnitudes for Effect Statistics’. Available at: https://www.sportsci.org/resource/stats/effectmag.html.

Hopkins, Will (2015) ‘Spreadsheers for Analysis of Validity and Reliability’, *Sportscience*, 19, pp. 36–42.

Hortobagyi, T. *et al.* (2001) ‘Effects of standard and eccentric overload strength training in young women’:, *Medicine and Science in Sports and Exercise*, pp. 1206–1212. Available at: https://doi.org/10.1097/00005768-200107000-00020.

Hughes, G.A. and Ramer, L.M. (2019) ‘DURATION OF MYOFASCIAL ROLLING FOR OPTIMAL RECOVERY, RANGE OF MOTION, AND PERFORMANCE: A

SYSTEMATIC REVIEW OF THE LITERATURE', *International Journal of Sports Physical Therapy*, 14(6), pp. 845–859.

Isner-Horobeti, M.-E. *et al.* (2013) 'Eccentric Exercise Training: Modalities, Applications and Perspectives', *Sports Medicine*, 43(6), pp. 483–512. Available at: https://doi.org/10.1007/s40279-013-0052-y.

Jones, Andrew *et al.* (2015) 'Effects of foam rolling on vertical jump performance', *International Journal of Kinesiology and Sports Science*, 3(3), pp. 38–42. Available at: https://doi.org/10.7575/aiac.ijkss.v.3n.3p.38.

Kalichman, L. and Ben David, C. (2017) 'Effect of self-myofascial release on myofascial pain, muscle flexibility, and strength: A narrative review', *Journal of Bodywork and Movement Therapies*, 21(2), pp. 446–451. Available at: https://doi.org/10.1016/j.jbmt.2016.11.006.

Kelly, D.M. *et al.* (2020) 'Quantification of training and match-load distribution across a season in elite English Premier League soccer players', *Science and Medicine in Football*, 4(1), pp. 59–67. Available at: https://doi.org/10.1080/24733938.2019.1651934.

Kelly, Shane and Beardsley, Chris (2016) 'Specific and cross-over effects of foam rolling on ankle dorsiflexion range of motion', *The International Journal of Sports Physical Therapy*, 11(4), pp. 544–551.

Konrad, A., Tilp, M. and Nakamura, M. (2021) 'A Comparison of the Effects of Foam Rolling and Stretching on Physical Performance. A Systematic Review and Meta-Analysis', *Frontiers in Physiology*, 12, p. 720531. Available at: https://doi.org/10.3389/fphys.2021.720531.

Koo, T.K. and Li, M.Y. (2016) 'A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research', *Journal of Chiropractic Medicine*, 15(2), pp. 155–163. Available at: https://doi.org/10.1016/j.jcm.2016.02.012.

Kotuła, K. *et al.* (2023) 'Sprint Resisted and Assisted Priming for Peak Performance', *Journal of Strength and Conditioning Research* [Preprint]. Available at: https://doi.org/10.1519/JSC.0000000000004557.

Kratky, S. and Müller, E. (2013) 'Sprint Running With a Body-Weight Supporting Kite Reduces Ground Contact Time in Well-Trained Sprinters', *Journal of Strength and Conditioning Research*, 27(5), pp. 1215–1222. Available at: https://doi.org/10.1519/JSC.0b013e3182654a30.

Kruse, A. *et al.* (2021) 'Stimuli for Adaptations in Muscle Length and the Length Range of Active Force Exertion—A Narrative Review', *Frontiers in Physiology*, 12, p. 742034. Available at: https://doi.org/10.3389/fphys.2021.742034.

Lippi, G. *et al.* (2008) 'Updates on improvement of human athletic performance: focus on world records in athletics', *British Medical Bulletin*, 87(1), pp. 7–15. Available at: https://doi.org/10.1093/bmb/ldn029.

Loturco, I. *et al.* (2024) ‘Effects of Different Conditioning Activities on the Sprint Performance of Elite Sprinters: A Systematic Review With Meta-Analysis’, *International Journal of Sports Physiology and Performance*, 19(7), pp. 712–721. Available at: https://doi.org/10.1123/ijspp.2024-0005.

Lüscher, H.R., Ruenzel, P. and Henneman, E. (1983) ‘Composite EPSPs in motoneurons of different sizes before and during PTP: implications for transmission failure and its relief in Ia projections.’, *Journal of Neurophysiology*, 49(1), pp. 269–289. Available at: https://doi.org/10.1152/jn.1983.49.1.269.

MacDonald, G.Z. *et al.* (2013) ‘An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force’, *Journal of Strength and Conditioning Research*, 27(3), pp. 812–821. Available at: https://doi.org/10.1519/JSC.0b013e31825c2bc1.

Mara, J.K. *et al.* (2017) ‘The acceleration and deceleration profiles of elite female soccer players during competitive matches’, *Journal of Science and Medicine in Sport*, 20(9), pp. 867–872. Available at: https://doi.org/10.1016/j.jsams.2016.12.078.

Marks, F., Klingmüller, U. and Müller-Decker, K. (2017) *Cellular signal processing: an introduction to the molecular mechanisms of signal transduction*. Second edition. New York: Garland Science, Taylor & Francis Group.

Marocolo, M. *et al.* (2019) ‘Ischemic preconditioning and exercise performance: shedding light through smallest worthwhile change’, *European Journal of Applied Physiology*, 119(10), pp. 2123–2149. Available at: https://doi.org/10.1007/s00421-019-04214-6.

Mattes, K., Wolff, S. and Alizadeh, S. (2021) ‘Kinematic Stride Characteristics of Maximal Sprint Running of Elite Sprinters – Verification of the “Swing-Pull Technique”’, *Journal of Human Kinetics*, 77, pp. 15–24. Available at: https://doi.org/10.2478/hukin-2021-0008.

Maughan, R.J. (2018) ‘IOC Medical and Scientific Commission reviews its position on the use of dietary supplements by elite athletes’, *British Journal of Sports Medicine*, 52(7), pp. 418–419. Available at: https://doi.org/10.1136/bjsports-2018-099199.

McFarland, I. *et al.* (2016) ‘Relationship of Two Vertical Jumping Tests to Sprint and Change of Direction Speed among Male and Female Collegiate Soccer Players’, *Sports*, 4(1), p. 11. Available at: https://doi.org/10.3390/sports4010011.

McKenney, K. *et al.* (2013) ‘Myofascial Release as a Treatment for Orthopaedic Conditions: A Systematic Review’, *Journal of Athletic Training*, 48(4), pp. 522–527. Available at: https://doi.org/10.4085/1062-6050-48.3.17.

Meldrum, M.L. (2000) ‘A BRIEF HISTORY OF THE RANDOMIZED CONTROLLED TRIAL’, *Hematology/Oncology Clinics of North America*, 14(4), pp. 745–760. Available at: https://doi.org/10.1016/S0889-8588(05)70309-9.

Merrigan, J. *et al.* (2022) ‘Application of Accentuated Eccentric Loading to Elicit Acute and Chronic Velocity and Power Improvements: A Narrative Review’, *International Journal of Strength and Conditioning*, 2(1). Available at: https://doi.org/10.47206/ijsc.v2i1.80.

Mikesky, A.E. *et al.* (2002) ‘Acute effects of The Stick on strength, power, and flexibility’, *Journal of Strength and Conditioning Research*, 16(3), pp. 446–450.

Modric *et al.* (2019) ‘Analysis of the Association between Running Performance and Game Performance Indicators in Professional Soccer Players’, *International Journal of Environmental Research and Public Health*, 16(20), p. 4032. Available at: https://doi.org/10.3390/ijerph16204032.

Moher, D. *et al.* (2010) ‘CONSORT 2010 Explanation and Elaboration: updated guidelines for reporting parallel group randomised trials’, *BMJ*, 340(mar23 1), pp. c869–c869. Available at: https://doi.org/10.1136/bmj.c869.

Moore, C.A. *et al.* (2007a) ‘Acute Effects of Augmented Eccentric Loading on Jump Squat Performance’, *The Journal of Strength and Conditioning Research*, 21(2), p. 372. Available at: https://doi.org/10.1519/R-18605.1.

Moore, C.A. *et al.* (2007b) ‘Acute Effects of Augmented Eccentric Loading on Jump Squat Performance’, *The Journal of Strength and Conditioning Research*, 21(2), p. 372. Available at: https://doi.org/10.1519/R-18605.1.

Murad, M.H. *et al.* (2016) ‘New evidence pyramid’, *Evidence Based Medicine*, 21(4), pp. 125–127. Available at: https://doi.org/10.1136/ebmed-2016-110401.

Murphy, A. *et al.* (2023) ‘The Effects of Strength and Conditioning Interventions on Sprinting Performance in Team Sport Athletes: A Systematic Review and Meta-Analysis’, *Journal of Strength and Conditioning Research*, 37(8), pp. 1692–1702. Available at: https://doi.org/10.1519/JSC.0000000000004440.

Murray, A.M. *et al.* (2016) ‘SIXTY SECONDS OF FOAM ROLLING DOES NOT AFFECT FUNCTIONAL FLEXIBILITY OR CHANGE MUSCLE TEMPERATURE IN ADOLESCENT ATHLETES’, *International Journal of Sports Physical Therapy*, 11(5), pp. 765–776.

Ojasto, T. and Häkkinen, K. (2009) ‘Effects of Different Accentuated Eccentric Load Levels in Eccentric-Concentric Actions on Acute Neuromuscular, Maximal Force, and Power Responses’, *Journal of Strength and Conditioning Research*, 23(3), pp. 996–1004. Available at: https://doi.org/10.1519/JSC.0b013e3181a2b28e.

de Oliveira, L.F. *et al.* (2022) ‘Extracellular Buffering Supplements to Improve Exercise Capacity and Performance: A Comprehensive Systematic Review and Meta-analysis’, *Sports Medicine*, 52(3), pp. 505–526. Available at: https://doi.org/10.1007/s40279-021-01575-x.

Page, M.J. *et al.* (2016) ‘Empirical Evidence of Study Design Biases in Randomized Trials: Systematic Review of Meta-Epidemiological Studies’, *PLOS ONE*. Edited by R.W. Scherer, 11(7), p. e0159267. Available at: https://doi.org/10.1371/journal.pone.0159267.

Peacock, C.A. *et al.* (2014) ‘An acute bout of self-myofascial release in the form of foam rolling improves performance testing’, *International Journal of Exercise Science*, 7(3), pp. 202–211.

Pecci, J. *et al.* (2023) ‘Effects of 6 weeks in-season flywheel squat resistance training on strength, vertical jump, change of direction and sprint performance in professional female soccer players’, *Biology of Sport*, 40(2), pp. 521–529. Available at: https://doi.org/10.5114/biolsport.2023.118022.

Pehar, M. *et al.* (2017) ‘Evaluation of different jumping tests in defining position-specific and performance-level differences in high level basketball players’, *Biology of Sport*, 3, pp. 263–272. Available at: https://doi.org/10.5114/biolsport.2017.67122.

Petrakos, G., Egan, B. and Morin, J.-B. (2016) ‘Resisted Sled Sprint Training to Improve Sprint Performance: A Systematic Review.’, *Sports Medicine*, 46(3), pp. 381–400.

Phillips, J *et al.* (2018) ‘Effect of varying self-myofascial release duration on subsequent athletic performance’, *Journal of Strength and Conditioning Research*, XX(X), pp. 000–000.

Preston, R.R. and Wilson, T.E. (2013) *Physiology*. International ed. Philadelphia, Pa.: Lippincott Williams & Wilkins.

Prieske, O. *et al.* (2020) ‘Time to Differentiate Postactivation “Potentiation” from “Performance Enhancement” in the Strength and Conditioning Community.’, *Sports Medicine*, 50(9), pp. 1559–1565.

Ramirez-Campillo, R. *et al.* (2020) ‘Effects of Plyometric Jump Training on Jump and Sprint Performance in Young Male Soccer Players: A Systematic Review and Meta-analysis’, *Sports Medicine*, 50(12), pp. 2125–2143. Available at: https://doi.org/10.1007/s40279-020-01337-1.

Richman, E.D., Tyo, B.M. and Nicks, C.R. (2019) ‘Combined Effects of Self-Myofascial Release and Dynamic Stretching on Range of Motion, Jump, Sprint, and Agility Performance’, *Journal of Strength and Conditioning Research*, 33(7), pp. 1795–1803. Available at: https://doi.org/10.1519/JSC.0000000000002676.

Rodríguez-Lorenzo, L. *et al.* (2016) ‘Role of Vertical Jumps and Anthropometric Variables in Maximal Kicking Ball Velocities in Elite Soccer Players’, *Journal of Human Kinetics*, 53(1), pp. 143–154. Available at: https://doi.org/10.1515/hukin-2016-0018.

Ryder, J.W. *et al.* (2007) ‘Enhanced Skeletal Muscle Contraction with Myosin Light Chain Phosphorylation by a Calmodulin-sensing Kinase’, *Journal of Biological Chemistry*, 282(28), pp. 20447–20454. Available at: https://doi.org/10.1074/jbc.M702927200.

Sagelv, E.H. *et al.* (2020) ‘Flywheel squats versus free weight high load squats for improving high velocity movements in football. A randomized controlled trial’, *BMC Sports Science, Medicine and Rehabilitation*, 12(1), p. 61. Available at: https://doi.org/10.1186/s13102-020-00210-y.

Sağiroğlu, İ. (2017) ‘Acute effects of applied local vibration during foam roller exercises on lower extremity explosive strength and flexibility performance’, *Eurpoean Journal of Physical Education and Sport Science*, 3(11), pp. 20–31. Available at: https://doi.org/10.5281/ZENODO.893585.

Sale, D.G. (2002) ‘Postactivation potentiation: role in human performance. / Postactivation potentiation: role dans la performance humaine.’, *Exercise & Sport Sciences Reviews*, 30(3), pp. 138–143.

Schulz, K.F. and Grimes, D.A. (2002) ‘Sample size slippages in randomised trials: exclusions and the lost and wayward’, *The Lancet*, 359(9308), pp. 781–785. Available at: https://doi.org/10.1016/S0140-6736(02)07882-0.

Scott, D., Norris, D. and Lovell, R. (2020) ‘Dose–Response Relationship Between External Load and Wellness in Elite Women’s Soccer Matches: Do Customized Velocity Thresholds Add Value?’, *International Journal of Sports Physiology and Performance*, 15(9), pp. 1245–1251. Available at: https://doi.org/10.1123/ijspp.2019-0660.

Seitz, L.B. and Haff, G.G. (2016) ‘Factors Modulating Post-Activation Potentiation of Jump, Sprint, Throw, and Upper-Body Ballistic Performances: A Systematic Review with Meta-Analysis’, *Sports Medicine*, 46(2), pp. 231–240. Available at: https://doi.org/10.1007/s40279-015-0415-7.

Shaher A I Shalfawi *et al.* (2012) ‘Assessing test-retest reliability of the portable Brower Speed Trap II testing system’, *Kinesiology*, 44, pp. 24–30.

Sheppard, J. *et al.* (2008a) ‘The Effect of Training with Accentuated Eccentric Load Counter-Movement Jumps on Strength and Power Characteristics of High-Performance Volleyball Players’, *International Journal of Sports Science & Coaching*, 3(3), pp. 355–363. Available at: https://doi.org/10.1260/174795408786238498.

Sheppard, J. *et al.* (2008b) ‘The Effect of Training with Accentuated Eccentric Load Counter-Movement Jumps on Strength and Power Characteristics of High-Performance Volleyball Players’, *International Journal of Sports Science & Coaching*, 3(3), pp. 355–363. Available at: https://doi.org/10.1260/174795408786238498.

Sheppard, J.M. and Young, K. (2010) ‘Using Additional Eccentric Loads to Increase Concentric Performance in the Bench Throw’, *Journal of Strength and Conditioning Research*, 24(10), pp. 2853–2856. Available at: https://doi.org/10.1519/JSC.0b013e3181e2731b.

Slimani, M., Paravlić, A. and Bragazzi, N.L. (2017) ‘Data concerning the effect of plyometric training on jump performance in soccer players: A meta-analysis’, *Data in Brief*, 15, pp. 324–334. Available at: https://doi.org/10.1016/j.dib.2017.09.054.

Snook, G.A. (1984) ‘The history of sports medicine. Part I’, *The American Journal of Sports Medicine*, 12(4), pp. 252–254. Available at: https://doi.org/10.1177/036354658401200402.

Southward, K., Rutherfurd-Markwick, K.J. and Ali, A. (2018) ‘The Effect of Acute Caffeine Ingestion on Endurance Performance: A Systematic Review and Meta–

Analysis', *Sports Medicine*, 48(8), pp. 1913–1928. Available at: https://doi.org/10.1007/s40279-018-0939-8.

Stone, M.H. *et al.* (2021) 'Periodization and Block Periodization in Sports: Emphasis on Strength-Power Training—A Provocative and Challenging Narrative', *Journal of Strength and Conditioning Research*, 35(8), pp. 2351–2371. Available at: https://doi.org/10.1519/JSC.0000000000004050.

Stull, J.T., Kamm, K.E. and Vandenboom, R. (2011) 'Myosin light chain kinase and the role of myosin light chain phosphorylation in skeletal muscle', *Archives of Biochemistry and Biophysics*, 510(2), pp. 120–128. Available at: https://doi.org/10.1016/j.abb.2011.01.017.

Su, E.Y.-S. *et al.* (2023) 'Musculoskeletal simulations to examine the effects of accentuated eccentric loading (AEL) on jump height', *PeerJ*, 11, p. e14687. Available at: https://doi.org/10.7717/peerj.14687.

Suchomel, T.J. *et al.* (2019) 'Implementing Eccentric Resistance Training—Part 1: A Brief Review of Existing Methods', *Journal of Functional Morphology and Kinesiology*, 4(2), p. 38. Available at: https://doi.org/10.3390/jfmk4020038.

Sullivan, K.M. *et al.* (2013) 'Roller-massager application to the hamstrings increases sit-and-reach range of motion within five to ten seconds without performance impairments', *International Journal of Sports Physical Therapy*, 8(3), pp. 228–236.

Taber, C.B. *et al.* (2021) 'Accentuated Eccentric Loading in the Bench Press: Considerations for Eccentric and Concentric Loading', *Sports*, 9(5), p. 54. Available at: https://doi.org/10.3390/sports9050054.

Thompson, K.M.A. *et al.* (2021) 'Moderate Load Resisted Sprints Do Not Improve Subsequent Sprint Performance in Varsity-Level Sprinters', *Journal of Strength and Conditioning Research*, 35(1), pp. 72–77. Available at: https://doi.org/10.1519/JSC.0000000000002524.

Tian, H. *et al.* (2022) 'Can Blood Flow Restriction Training Benefit Post-Activation Potentiation? A Systematic Review of Controlled Trials', *International Journal of Environmental Research and Public Health*, 19(19), p. 11954. Available at: https://doi.org/10.3390/ijerph191911954.

Tillin, N.A. and Bishop, D. (2009) 'Factors Modulating Post-Activation Potentiation and its Effect on Performance of Subsequent Explosive Activities':, *Sports Medicine*, 39(2), pp. 147–166. Available at: https://doi.org/10.2165/00007256-200939020-00004.

Timmins, R.G. *et al.* (2021) 'Sprinting, Strength, and Architectural Adaptations Following Hamstring Training in Australian Footballers', *Scandinavian Journal of Medicine & Science in Sports*, 31(6), pp. 1276–1289. Available at: https://doi.org/10.1111/sms.13941.

Tseng, K.-W. *et al.* (2021) 'Post-activation Performance Enhancement after a Bout of Accentuated Eccentric Loading in Collegiate Male Volleyball Players', *International*

Journal of Environmental Research and Public Health, 18(24), p. 13110. Available at: https://doi.org/10.3390/ijerph182413110.

TURNER, A.P. *et al.* (2015) 'POSTACTIVATION POTENTIATION OF SPRINT ACCELERATION PERFORMANCE USING PLYOMETRIC EXERCISE.', *Journal of Strength & Conditioning Research*, 29(2), pp. 343–350.

Turnes, T. *et al.* (2019) 'The Impact of Preconditioning Strategies Designed to Improve 2000-m Rowing Ergometer Performance in Trained Rowers: A Systematic Review and Meta-Analysis', *International Journal of Sports Physiology and Performance*, 14(7), pp. 871–879. Available at: https://doi.org/10.1123/ijspp.2019-0247.

Van Den Tillaar, R., Teixeira, A. and Marinho, D. (2017) 'Acute effect of resisted sprinting upon regular sprint performance', *Acta Kinesiologiae Universitatis Tartuensis*, 23, pp. 19–33. Available at: https://doi.org/10.12697/akut.2017.23.02.

Vogt, M. and Hoppeler, H.H. (2014) 'Eccentric exercise: mechanisms and effects when used as training regime or training adjunct', *Journal of Applied Physiology*, 116(11), pp. 1446–1454. Available at: https://doi.org/10.1152/japplphysiol.00146.2013.

Wagle, J.P. *et al.* (2017) 'Accentuated Eccentric Loading for Training and Performance: A Review', *Sports Medicine*, 47(12), pp. 2473–2495. Available at: https://doi.org/10.1007/s40279-017-0755-6.

Walker, S. *et al.* (2016) 'Greater Strength Gains after Training with Accentuated Eccentric than Traditional Isoinertial Loads in Already Strength-Trained Men', *Frontiers in Physiology*, 7. Available at: https://doi.org/10.3389/fphys.2016.00149.

Walker, S. *et al.* (2020) 'Increased fascicle length but not patellar tendon stiffness after accentuated eccentric-load strength training in already-trained men', *European Journal of Applied Physiology*, 120(11), pp. 2371–2382. Available at: https://doi.org/10.1007/s00421-020-04462-x.

Wang, F. *et al.* (2022) 'Acute effects of vibration foam rolling and local vibration during warm-up on athletic performance in tennis players', *PLOS ONE*. Edited by A.P. Lavender, 17(5), p. e0268515. Available at: https://doi.org/10.1371/journal.pone.0268515.

Warneke, K. *et al.* (2023) 'Are Acute Effects of Foam-Rolling Attributed to Dynamic Warm Up Effects? A Comparative Study', *Journal of Sports Science and Medicine*, pp. 180–188. Available at: https://doi.org/10.52082/jssm.2023.180.

Weiss, M. *et al.* (2016) 'One hundred and fifty years of sprint and distance running – Past trends and future prospects', *European Journal of Sport Science*, 16(4), pp. 393–401. Available at: https://doi.org/10.1080/17461391.2015.1042526.

Whelan, N., O'Regan, C. and Harrison, A.J. (2014) 'Resisted Sprints Do Not Acutely Enhance Sprinting Performance', *Journal of Strength and Conditioning Research*, 28(7), pp. 1858–1866. Available at: https://doi.org/10.1519/JSC.0000000000000357.

Wiewelhove, T. *et al.* (2019) ‘A Meta-Analysis of the Effects of Foam Rolling on Performance and Recovery’, *Frontiers in Physiology*, 10, p. 376. Available at: https://doi.org/10.3389/fphys.2019.00376.

Winwood, P.W. *et al.* (2016) ‘The Acute Potentiating Effects of Heavy Sled Pulls on Sprint Performance’, *Journal of Strength and Conditioning Research*, 30(5), pp. 1248–1254. Available at: https://doi.org/10.1519/JSC.0000000000001227.

Xenofondos, Anthi, Patikas, Dimitrios, and Kotzamandis, Christos (2014) ‘On the mechanisms of post-activation potentiation: the contribution of neural factors’, *Journal of Physical Education and Sport*, 14(2), pp. 134–137.

Zabaloy, S. *et al.* (2022) ‘Muscle Activity, Leg Stiffness, and Kinematics During Unresisted and Resisted Sprinting Conditions.’, *Journal of Strength & Conditioning Research*, 36(7), pp. 1839–1846.

Zabaloy, S. *et al.* (2023) ‘Narrative Review on the Use of Sled Training to Improve Sprint Performance in Team Sport Athletes’, *Strength & Conditioning Journal*, 45(1), pp. 13–28. Available at: https://doi.org/10.1519/SSC.0000000000000730.

Zagatto, A. *et al.* (2022) ‘Drop jumps improve repeated sprint ability performances in professional basketball players’, *Biology of Sport*, 39(1), pp. 59–66. Available at: https://doi.org/10.5114/biolsport.2021.101128.

Zagatto, A.M. *et al.* (2022) ‘Drop jumps versus sled towing and their effects on repeated sprint ability in young basketball players.’, *BMC Sports Science, Medicine & Rehabilitation*, 14(1), pp. 1–11.

Zhi, G. *et al.* (2005) ‘Myosin light chain kinase and myosin phosphorylation effect frequency-dependent potentiation of skeletal muscle contraction’, *Proceedings of the National Academy of Sciences*, 102(48), pp. 17519–17524. Available at: https://doi.org/10.1073/pnas.0506846102.

Zisi, M. *et al.* (2022) ‘The Acute Effects of Heavy Sled Towing on Acceleration Performance and Sprint Mechanical and Kinematic Characteristics.’, *Sports (2075-4663)*, 10(5), pp. 77–77.

Zügel, M. *et al.* (2018) ‘Fascial tissue research in sports medicine: from molecules to tissue adaptation, injury and diagnostics: consensus statement’, *British Journal of Sports Medicine*, 52(23), pp. 1497–1497. Available at: https://doi.org/10.1136/bjsports-2018-099308.