Research review

by Sean Maloney

Volume 2

Welcome to *Research Review*, your monthly round-up of what's hot in sport and exercise science research.

We're hitting both ends of the spectrum this time, so power athletes and endurance athletes take note. This issue will feature research investigating concepts such the training effect of incline plyometrics, minimalist footwear on running economy and optimising dosing for caffeine supplementation.

Remember: Train hard, train SMART!

Study 1

Incline plyometrics may improve explosive plantar flexion

In our last issue we mentioned a study by Kannas *et al.* which investigated the biomechanics of performing plyometric drills on an incline surface. Subsequent findings by the same Greek research team are soon to be published in the *European Journal of Applied Physiology* and appear to confirm their hypothesis that these drills can be more effective for developing explosive plantar flexion.

Twenty male subjects were split into two training groups, half performing plyometrics on an incline surface (15°) and the other half on a flat surface. The training programme consisted of a series of stiff-legged jumps (8–10 sets of 10 maximal jumps) on the designated surface. Subjects completed four sessions per week for a period of 4 weeks. The incline group showed significant improvements in fast depth jump performance (17% from a 20cm drop, 14% from a drop of 40cm), with activity of the gastrocnemius during the propulsion phase also increased during these jumps. Improvements in squat, countermovement and slow depth jump performances were not significant. Fast depth jumps were classified by <50° of knee flexion on impact and slow depth jumps by >60° of flexion.

- *Outcome*: incline plyometrics appear a viable training modality for improving explosive plantar flexion and reactive strength.

Reference

Kannas TM, Kellis E, Amiridis IG. Incline plyometrics-induced improvement of jumping performance. *Eur J App Phys*, 2012, **112**, 2353–2361.

Study 2

Fibre type shifting – what's actually possible?

Type II fibres (categorised as either type IIa or type IIx) are designed for high-force and high-velocity function. These types of fibres are particularly prevalent in strength and power athletes. Conversely, type I fibres are built to function for long durations – and predominate in endurance athletes. For athletes, the ability to train to shift fibre type would be of significant benefit. Research has reached a general consensus confirming the potential for conversion between type IIa and type IIx muscle fibres; however, the possibility of conversion between type I and type II fibres is less clear. Wilson *et al.* sought to combine data from current research and determine the extent to which exercise can affect fibre type composition.

Whilst a body of evidence discounts the potential for type I/type II interconversion, the results of several studies imply that this *may* be possible with specific and concentrated programming. Perhaps unsurprisingly, a shift towards type II fibres may be facilitated by the performance of power exercises. This conversion may also be facilitated by the thyroid hormone triiodothyronine (commonly known as T3). A transition towards type I fibres may be facilitated by high-volume, long-duration endurance training.

THE SCIENCE

Muscle fibre type can be classified in three different ways: *myosin ATPase staining, myosin heavy chain identification, and biochemically* [1–3].

Advances *in myosin ATPase staining* techniques now mean that seven separate fibre types can be identified [1]. In order, from slowest to fastest, these are: I, IC, IIC, IIAC, IIA, IIAB, and IIB.

Three *myosin heavy chain* forms were originally identified: MHCI, MHCIIa and MHCIIx (previously known as MHCIIb), and these correspond to the original I, IIa and IIb types identified by staining [2]. It appears that type IC, IIC and IIAC coexpress MHCI and MHCIIa genes to varying degrees, and type IIAB coexpresses MHCIIa.

Biochemically, fibres are typed as slow-oxidative (SO), fast-oxidative-glycolytic (FOG) or fast-glycolytic (FG) [3]. Type I fibres correlate well with SO fibres; however, variability in the predominance of energy systems means that type IIA and type IIB fibres cannot be used interchangeably with FOG and FG.

1. Scott W, Stevens J, Binder-Macleod SA. Human skeletal muscle fiber type classifications. *Phys Ther*, 2001, **81**, 1810–1816.
2. Staron RS. Human skeletal muscle fiber types: delineation, development, and distribution. *Can J Appl Physiol*, 1997, **22**, 307–327.
3. Pette D, Peuker H, Staron RS. The impact of biochemical methods for single muscle fibre analysis. *Acta Physiol Scand*, 1999, **166**, 261–277.

- *Outcome*: the potential for type I/type II interconversion as a consequence of training is still largely unclear: longitudinal studies over several years or more appear necessary.

Reference

Wilson JM, Loenneke JP, Jo E *et al.* A brief review: the effects of endurance, strength, and power training on muscle fiber type shifting. *J Strength Cond Res*, 19 September 2011 [epub ahead of print].

Study 3

Minimalist footwear improves running economy

Part of the appeal of minimalist – or barefoot – running is the potential for greater energy return from the foot and ankle complex. In theory, this should improve running economy. Previous studies have investigated the effect of footwear on running economy, although did not control for factors such as shoe mass, stride frequency and running style (forefoot versus rearfoot striking). Researchers at Harvard University aimed to address these experimental concerns.

The study measured the biomechanics and running economy of 15 habitually 'minimalist' runners in four separate trials: a) standard trainers, forefoot striking; b) standard trainers, rearfoot striking; c) minimalist trainers, forefoot striking; d) minimalist trainers, rearfoot striking. Minimalist trainers were 2.4% more economical when forefoot striking and 3.3% more economical when rearfoot striking. Achilles tendon strain and knee flexion were also reduced in minimalist footwear. It was deemed likely that these improvements are a consequence of greater elastic energy return from the lower extremity. Forefoot striking was not more economical than rearfoot striking.

- *Outcome*: minimalist footwear may confer small improvements in running economy that are independent of running style.

Reference

Perl DP, Daoud AI, Lieberman DE. Effects of footwear and strike type on running economy. *Med Sci Sports Exerc*, 3 January 2012 [epub ahead of print].

Study 4

Resisted movement training – does it work?

The utilisation of training tools such as sleds and bungees has increased over the past few years. These tools allow an adjustable resistance to be applied to dynamic, sport-specific movement patterns. The rationale is that resisted movement training provides a greater carryover to athletic performance. Hrysomallis has conducted a review of the literature to date, to evaluate its effectiveness.

Weighted jump squats at a variety of loads (30%–80%1RM) have elicited improvements in jump performance although have not proven superior to plyometric training. Jump training performed with elastic resistance does not appear beneficial to performance. Resisted sprint training has been demonstrated to improve sprint performance although seems no more effective than regular sprint training. Limited research suggests that sled-resisted training may be more effective in training the initial acceleration phase; however, further research is necessary to determine its effectiveness.

- *Outcome*: on the whole, resisted movement training does not appear superior to other training modalities for improving jump or sprint performance.

Reference

Hrysomallis C. The effectiveness of resisted movement training on sprinting and jumping performance. *J Strength Cond Res*, 2012, **26,** 299–306.

Study 5

Optimising caffeine dosage

The ergogenic potential of caffeine to endurance performance has been pretty well established. Previous studies have directed current recommendations for caffeine supplementation, which currently fall within a range of 3–6mg/kg. The ability to further optimise this dose would be of real interest to endurance athletes. A team of Australian researchers have attempted to determine at which end of the recommendation spectrum this optimal dose lies.

Sixteen well-trained cyclists performed three separate time trials following the ingestion of a placebo, 3mg/kg, or 6mg/kg of caffeine. These were taken in the form of capsules, 90 minutes prior to performance. The time trial was designated by a set amount of work equivalent to 75% of the individual's peak sustainable power output for 60 minutes, and lasted for a similar duration. Time trial performance was improved in both caffeine trials, by 4.2% in the 3mg/kg condition and 2.9% in the 6mg/kg condition. Differences in the two caffeine trials were not significant. Heart rate was elevated following caffeine ingestion although perceived exertion was not affected.

- *Outcome*: trained endurance cyclists may benefit from the ingestion of caffeine at a dose of 3mg/kg. Doubling the dose to 6mg/kg confers no additional performance benefit.

Reference

Desbrow B, Biddulph C, Devlin B *et al.* The effects of different doses of caffeine on endurance cycling time trial performance. *J Sport Sci*, 2012, **30**, 115–120.

Study 6

Minimal effect of ionised and non-ionised compression garments

Whilst the use of compression garments in sport and exercise is widespread, research supporting their ergogenic potential is split. Recent advances in clothing technology have seen manufacturers incorporating negatively charged ions into the fabric, which it is hypothesised may improve blood flow. No studies had previously investigated the effects of wearing ionised compression clothing.

Ten trained triathletes or cyclists performed three sprint trials and three endurance trials wearing standard running tights, non-ionised compression tights and ionised compression tights. Garment type was found to have no effect on peak power, mean power and fatigue during the sprint trials. Similarly, there was no effect of garment type on time trial performance, mean VO_2 and heart rate responses during the endurance trials. Interestingly, blood lactate was lower in the non-ionised compression condition during these endurance trials. Given that the ionised and non-ionised tights produced almost identical compressive forces, the mechanism for this reduction is unclear.

- *Outcome*: the study does not support the notion that compression garments improve aerobic or anaerobic performance.

Reference

Burden RJ, Glaister M. The effects of ionised and non-ionised compression garments on sprint and endurance cycling. *J Strength Cond Res*, **23** November 2011 [epub ahead of print].

See page 9 for more on compression garments.

Study 7

Effect of training volume on strength

Much debate rages within the strength and conditioning community as to the optimal number of sets to perform for a given exercise or muscle group. Whilst the literature has compared single-set to multiple-set training, these multiple-set protocols have only investigated the performance of three to four sets. Resistance trained populations will commonly perform a volume of work far in excess of four sets per muscle group. Robbins *et al.* investigated the effects of high-volume (eight-set) strength training on subsequent strength performance and in comparison to one-set and four-set training.

Thirty-two strength-trained men were randomly assigned to either a one-set, four-set or eight-set training regimen. Training sessions were completed twice per week and consisted primarily of the back squat exercise. Subjects performed repetitions at 80%1RM, which was re-tested after 3 weeks of training, until volitional fatigue and for the given number of sets. Both the four-set and eight-set conditions improved 1RM squat performance after 3 weeks of training; and all three training conditions had improved squat performances following the full 6-week training programme. Improvements achieved by the eight-set group were greater than those achieved by the one-set group. Improvements of the four-set group were not greater than the one-set group.

- *Outcome*: it appears that higher-volume protocols are more effective for lower-body strength development in trained individuals

Reference

Robbins DW, Marshall PWM, McEwen M. The effect of training volume on lower-body strength. *J Strength Cond Res*, 2012, **26**, 34–39.

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