November 2018 | Issue #25

THE PERFORMANCE DIGEST

A review of the latest sports performance research

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Welcome to the
PERFORMANCE DIGEST

OWEN WALKER
Founder and Director of
Science for Sport

If you're reading this right now, then I am seriously honoured you decided to invest in yourself and join the Performance Digest. I am extremely thankful for every single member who chooses to join us on our relentless quest to improve this industry for the better. Without you, this would simply not be possible; so thank you.

LATEST NEWS

1) Big things to come!

This month I just wanted to let you know that we (Science for Sport) have very big things to come which we're very excited about, so keep you eyes peeled :)

Thanks for reading, and for being a member :)
Owen Walker

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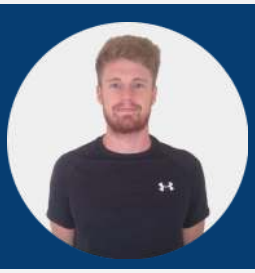
Research Reviewers



Owen Walker
MSc*D CSCS

Chief Editor

Owen is the founder and director of Science for Sport. He was formerly the Head of Academy Sports Science and Strength & Conditioning at Cardiff City Football Club, and an interim Sports Scientist for the Welsh FA.

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PhD Candidate CSCS ASCA L2

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Fran is a strength and conditioning coach at the Glasgow Warriors, Scotland. He is also a PhD candidate at Waikato University, New Zealand, a performance consultant to the Portuguese Rugby Union, and a published author.

Dr. Will Vickery
PhD

The Science of Coaching

Will is a Senior Lecturer of Sport Coaching at the University of Northumbria: Newcastle Upon Tyne. Prior to this he has worked with Cricket NSW and Cricket Australia in an array of roles ranging from a sport scientist, development coach and a strength and conditioning coach.

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MSc UKAD Advisor

Youth Development

Tom is the Head of Athletic Development at St. Peter's R.C High School in Gloucester, England. He has an MSc in Applied Strength and Conditioning from Hartpury College. He has also worked with Gloucester Rugby Club as an Academy S&C Assistant and in professional boxing, semi-professional football, and GB Equine.

James de Lacey
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Strength & Conditioning

James is currently the Head Strength & Conditioning Coach for the Romanian Rugby Union. He has previously worked in America's professional rugby competition Major League Rugby with Austin Elite and the NZ Women's National Rugby League Team. He is a published author and has completed a MSc in Sport & Exercise Science from AUT, Auckland, NZ.

James Morehen
PhD Candidate

Nutrition

James is a SENr registered performance nutritionist, currently completing his PhD at Liverpool John Moores University. He is also a Performance Nutritionist for the English Football Association alongside the England national squads (men's and women's)

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BSc

Technology & Monitoring

Carl is currently the lead sport technologist for SpikesOnly.com, and focuses his time on testing elite athletes and using technology to maximise human performance. Carl has coached Track and Field at every level, and also has significant expertise in performance data, including the practical application of equipment and software.

Dr. Stephanie Allen
PT, DPT, OCS, CFSC

Injury Prevention & Rehab

Stephanie is a Physical Therapist who graduated from Ithaca College and is working at Boston PT & Wellness. She is passionate about strength & conditioning and how it plays into rehab, and is also a member of the Strength Faction program.

Audio
REVIEW

S&C in Schools

A recap on what we know and hope to find out from future research.

with Tom Green

WHAT WE DICUSS

In this episode of the "Audio Review", Tom discusses S&C in schools and why it's so important to have.

In this episode, you will learn:

- The background of S&C in schools.
- Why it's important to have S&C in schools.
- Programmes which are already in place.
- Future research which will take S&C in schools to the next level.

Episode length = 49 minutes

A bit about **Tom**

Tom is the Head of Athletic Development at St. Peter's R.C High School in Gloucester, England. He has an MSc in Applied Strength and Conditioning from Hartpury College. He has also worked with Gloucester Rugby Club as an Academy S&C Assistant and in professional boxing, semi-professional football, and GB Equine.

Listen Now

The Science of COACHING

Where should a coach focus their attention?

The research doesn't always reflect the real world.

[Abstract]

INTRODUCTION

How a coach delivers instructions to an athlete is a topic which has been previously covered within this section of the Performance Digest, with the typical recommendation that coaches should provide instructions "which direct toward the outcome of the movement (i.e. external focus of attention) rather than the mechanics of the movement (i.e. internal focus of attention)".

This is not a new way of thinking when it comes to providing instructions, and a significant amount of research also even supports this (**HERE** and **HERE**). What is not usually considered within this research, however, is the skill being performed and whether an external focus of attention is suitable for that particular skill. For example, within sports such as athletics, the skill of running does not have an identifiable "end point", and therefore, in some cases, it may be that an internal focus of attention is more suitable as the coach may be unable to highlight where the athlete should focus their attention. Team-based sports typically include a goal or target to aim towards and, therefore, may tend to provide a greater opportunity for coaches to include a more external focus of attention for the purposes of improving performance. With this being the case, the aim of this study was to determine whether the coaches used an internal or external focus of attention when providing instructions and feedback to baseball pitchers.

WHAT THEY FOUND

To understand the focus of attention used by the coaches, the training sessions of 6 experienced baseball coaches who work with elite youth teams were recorded. This was combined with a series of questionnaires which were designed to gain an understanding from the athlete's perspective about their ability to consciously monitor and control movements and their focus of attention. The main results included:

⇒ Of the 1,699 individual coach's statements, only 31% invoked an external focus of attention.

⇒ Based on the results of the first questionnaire, athletes generally lent toward an internal focus of attention.

⇒ When referring to the usefulness of the instructions provided by the coach, athletes indicated that only 4 (out of 117 recollected during analysis) of the instructions that were deemed helpful by the players in increasing their throwing velocity were instructions with an external focus of attention.

WHAT THIS MEANS

As stated by the authors, more than two-thirds of the instructions or feedback provided to the athletes invoked an internal, as opposed to an external, focus of attention. This implies that most instructions were directed at the movement of the pitchers themselves as opposed to where the ball ended up.

The results also indicated that the athletes were more inclined to use an internal focus of attention themselves when trying to correct or improve their own performance. Despite the significant amount of evidence which highlights the positive effects of an external focus of attention on performance and skill development, coaches and athletes alike appear to prefer the use of an internal focus of attention. Unfortunately, what was not shown by the authors of the current study was whether the accuracy and velocity of the pitchers improved/decreased as a result of this use of external focus. What should be noted though is that there were no negative effects on performance that were reported based on the direction of athlete's attention.

Practical Takeaways

The results of the current study typically fly in the face of what current research suggests coaches should be doing when providing instructions or feedback to their athletes. Although it is suggested based on the current research available for the use of a more external focus of attention, this may not always be practical for coaches. The athletes themselves may be more responsive to the information when it is presented with an internal focus of attention, as opposed to external. Coaches are typically in the best position to understand their athletes and how they respond to coaching. One would be encouraged to gain as much information from the research and then make an informed decision on how this relates to your athletes and their ability.

Dr. Will Vickery

Will is a Senior Lecturer of Sport Coaching at the University of Northumbria in Newcastle Upon Tyne, U.K.

Strength & Conditioning

This month's top research in strength & conditioning.

RE-WARM-UPS: HOW INTENSE DO THEY NEED TO BE?

Yanaoka, T et al. (2018) Journal of Strength and Conditioning Research.

HOW LONG DOES IT TAKE TO TRANSFER STRENGTH FROM ONE LIMB TO THE OTHER WITH UNILATERAL TRAINING?

Barss, T et al. (2018) Journal of Applied Physiology.

HOW MUCH DETRAINING CAN WE EXPECT TO SEE DURING THE CHRISTMAS BREAK?

Rodriguez-Fernandez, A, et al. (2018) PLoS ONE.

[Abstract]

Re-Warm-Ups: How intense do they need to be?

OBJECTIVE
Many studies have reported declines in the amount of high-intensity running and sprinting after traditional passive half-time breaks. As shown in previous Performance Digests, re-warm-ups (RW) are a way to potentially improve subsequent exercise performance. While previous research has covered a half-time re-warm-up, there has been no research investigating the effects of low-intensity RW on subsequent exercise performance. Furthermore, 63% of sports scientists/fitness coaches in the English Premier League reported lack of time was one of the main limiting factors to not performing a RW. Therefore, the aim of this study was to investigate the effects of a very short duration RW (3-mins) on subsequent intermittent sport performance while comparing the effects of low- and moderate-intensity RWs.

WHAT THEY DID
11 healthy males (slightly active) participated in 3 trials in a randomised order. Initially, participants underwent a VO2max test on a cycle ergometer. The 3 trials involved 2 consecutive intermittent cycling ergometer exercises separated with a 15-min half-time. The first cycling period consisted of 20x2min periods of 15-sec rest, 25-sec unloaded cycling, 10-sec cycling at 130% VO2max, then 70-sec at 60% VO2max. The second intermittent period consisted of 10x2min periods of 10-sec rest, 5-sec sprint, and 10-sec at 50% VO2max.

The differences between the 3 trials were during the half-time period. The control group remained on the cycle ergometer for 15-mins of passive rest. The 2 experimental trials involved 11-mins passive rest followed by either cycling at 60% VO2max for 3-mins (60% RW) or cycling at 30% VO2max for 3-mins (30% RW). Each RW protocol was completed 1-min before the start of the second intermittent period. Work (calculated as mean power x duration of the sprint being 5-sec), EMG, muscle temp, gas analysis, HR, and RPE were measured.

WHAT THEY FOUND
Mean work was higher in both RW trials compared to the control. Muscle temperature was higher in the 60% RW protocol compared to the control and 30% RW protocols. Mean heart rate in the last minute of half-time was higher in RW trials compared to control. It was also higher in the 60% RW compare to 30% RW. Mean heart rate in the first 10-mins of the second intermittent period was higher in the 60% RW trial than in control. RPE was higher at the beginning of the second intermittent period in the 60% RW compared to 30% RW. Mean VCO2 and RER were higher in the 60% RW trial compared to control with 30% RW being comparable to control. Oxygen availability tended to be higher the both RW trials compared to control.

Practical Takeaways

The major findings of this study were that a very short duration re-warm-up increased intermittent cycling sprint performance compared with a passive half-time rest protocol. Furthermore, low-intensity (30% RW) was as effective for increasing cycling sprint performance as moderate intensity (60% RW). Physiological load was greater in the 60% RW compared with 30% RW as shown with VCO2max and RER, which suggests that 30% RW requires less anaerobic energy. RPE was also lower in the 30% RW trial, suggesting that a lower intensity RW may keep fatigue lower and energy stores higher for the following period of exercise.

Muscle temperature may not have been a reason for the increased second-period performance as the 30% RW trial showed no significant increases in muscle temperature, but did show comparable performance improvements to the 60% RW trial. Increased oxygen availability after the RW trials may have contributed to resynthesis of PCr during active recovery in the second cycling period. The article linked below covers half-time RWs along with nutritional strategies to maximise recovery for the second-half.

Want to learn more?
Then check these out...

James's Comments

"In previous issues of the Performance Digests, re-warm-ups have been performed in high-intensity bursts of jumps and sprints and/or through passive means such as heat garments. This paper now shows that low-intensity exercise is potentially sufficient enough to elicit improvements in subsequent sprint exercise. With the body of research currently published on re-warm-ups, it could be summed up as "doing something is better than doing nothing during a half-time period". However, this current paper was performed while cycling with a cycling re-warm-up. Whether cycling as a re-warm-up protocol would carry over to overground running sports is yet to be determined. Low-intensity re-warm-up may have a significant role when a first-half just played is more intense than usual, or if you have fewer subs on your bench due to injury—so keeping players fresh is important. Below is an example of how a low-intensity re-warm-up for a field-sport may look:

Dynamic sprint drill x10m (A skip, Primetimes, Ankle Bounds, High Knees, etc)

Dynamic mobility drill x10m (Warrior Lunge, Leg Swing, etc)

Walk/Jog back recovery between each exercise.

Repeat 3-6 times.

There is a short video example taken from soccer of a low-intensity re-warm-up that could also be utilised. Contact sports could also use low-level wrestling drills such as pummelling."

[Abstract]

How long does it take to transfer strength from one limb to the other with unilateral training?

OBJECTIVE
'Cross education' is a neural adaptation defined as the increase in strength or functional performance of an untrained limb after unilateral training. Unfortunately, there is limited evidence on the time-course of adaptation in the untrained contralateral limb. This limits the ability of practitioners to make effective recommendations for training-based rehabilitation. Therefore, the aim of this study was to determine the minimum number of training sessions to induce significant strength gains in both the trained and untrained limbs during unilateral handgrip training.

WHAT THEY DID
11 right-handed participants (6 female, 5 male) completed Experiment 1. 8 right-handed participants (2 female, 6 male) completed Experiment 2. A within-participant, repeated-measures design was used to improve the statistical power so that subjects completed 3 pre- and 1 post-test sessions. Each training session included 5x5 maximal voluntary isometric contractions (MVCs) using a handgrip dynamometer in their dominant hand. To track the time-course of force changes in the trained limb, MVC was recorded for every rep throughout the training programme. For the untrained limb, handgrip force was measured once every 3 sessions with a single contraction which was considered minimal interference. Experiment 1 consisted of 6 weeks of 'traditional' unilateral handgrip training 3x/week. Experiment 2 consisted of 'daily' unilateral handgrip training for 18 consecutive days to assess if strength gains in the untrained limb were related to total time of training or number of training sessions.

WHAT THEY FOUND
During the 'traditional' 6-week training, peak handgrip strength in the trained limb was significantly different than pre-testing average (PREavg) at session 9 (37.6 + 12.8kg vs 39.4 + 12.8kg) and remained different at the beginning of session 13 (37.6 + 12.8kg vs 40.6 + 13.0kg). The average session participants were significantly stronger than baseline and remained stronger for was 11.8 + 6.0 sessions. In the untrained limb, peak handgrip strength was first significantly different, and continued to be different than PREavg after the 4th week of handgrip training (34.8 + 12.6kg vs 36.9 + 13.9kg). Peak force increased 14.6 + 8.9% in the trained and 12.5 + 9.3% in the untrained limb.

During 'daily' training, POST handgrip strength was significantly greater than PREavg in the trained limb (48.0 + 13.9kg vs 52.8 + 15.7kg). In the untrained limb, POST handgrip strength was significantly greater than PREavg (45.6 + 12.4kg vs 49.3 + 14.0kg). In terms of time, the trained limb was significantly stronger and remained stronger from session 14.6 + 5.6, on average. In the untrained limb, handgrip strength was significantly stronger than PREavg after the 15th day. Peak force increased 9.7 + 8.7% in the trained and 7.8 + 6.8% in the untrained limb. Results indicated no difference in the % strength increase in untrained limbs between 'traditional' (12.5 + 9.3%) and 'daily' (7.8 + 6.8%) handgrip training.

Practical Takeaways

Untrained limb handgrip strength was significantly higher than baseline on the 15th day of training in the 'daily' training compared to the 12th session during the 'traditional' 6 weeks of training. However, session 12 occurred on approximately day 28 of 'traditional' training, which is almost twice the number of days compared to 'daily' training. Interestingly, peak force plateaued at 5 weeks of training during the 'traditional' approach while there was no plateau for 18 consecutive days of training, perhaps indicating that more than 18 sessions in a row are required to optimise strength increases in the untrained limb. Based on the number of sessions, 'traditional' training showed faster strength gains (12 vs 15 sessions).

For athletes with a forearm/wrist injury, return-to-play time is very important and training the uninjured limb may benefit the injured limb in terms of enhancing recovery and/or improving strength while not being able to directly train it. This potentially makes regaining strength when fully recovered even quicker. Since recovery time is likely to be very important in an athletic scenario with rehabbing an injured limb/athlete, a daily approach to cross education training is likely to be ideal for the uninjured arm. Due to the arm being trained every day, it would be best to keep it to 1-2 exercises, maximum. For example, a daily programme for an injured wrist may look like this for the uninjured arm:

A1) Gripper 5x5

B1) Hand Opening w/ Rubber Bands 3x10

If taking the 'traditional' approach, then more exercises along with volume may further improve strength.

Want to learn more?
Then check these out...

James's Comments

"This paper answers the question about the time-course for strength adaptations when it comes to the 'cross education' effect in the context of handgrip strength. Having said that, it is yet to be determined whether a similar time-course would occur in other muscle groups, movements, contraction types, and various selections of volume and intensity.

Training daily with heavy compound movements could potentially lead to a plateau much earlier and eventual burnout. The frequency, volume, and intensity to elicit 'cross education' should be decided on a case-by-case basis, where depending on the factors above, more or less of each will give the desired outcome of increased strength in the untrained, contralateral limb. It's also important to note that this study trained the dominant limb to see the effect on the non-dominant limb and, as such, strength improvements may be different when training the non-dominant limb."

[Abstract]

How much detraining can we expect to see during the Christmas break?

OBJECTIVE
The ability to perform short-duration multiple sprints with short recovery times has been termed as "repeated sprint ability" (RSA). RSA, along with intermittent high-intensity endurance, is considered to be crucial for soccer performance. In-season breaks (e.g. Christmas holidays) can lead to short-term detraining, potentially deconditioning the cardiovascular and neuromuscular systems which may impair RSA. Therefore, the aim of this study was to analyse if initial performance level (sprint speed) of soccer players adjusts RSA and intermittent endurance changes during 2-weeks of detraining (in-season Christmas break).

WHAT THEY DID
17 professional senior male soccer players and 16 young soccer players (age between 17-19) participated in a 2-week in-season break which took place during the mid-phase of the season (Christmas holidays). Players were asked to refrain from any type of physical activity other than the physical activity associated with daily life. The same training week was used before and after the 2-week Christmas break with the tests being planned into the training sessions to minimise any disturbance to the training plan. Day 1 (Wednesday) included tests of anthropometry and the RSA test. RSA involved 8x30m maximal sprints with 25-sec active recovery between sprints. 5-mins before the test, subjects performed a reference sprint which was used to score subsequent sprints. Day 2 (Friday) consisted of the Yo-Yo Intermittent recovery test (YYIR1) which was used to estimate VO2max.

WHAT THEY FOUND
YYIR1 performance was not significantly affected by the in-season break. Before the detraining break, professional players showed significantly better RSA best time than young players (~2.8%). The RSA best, mean, and total time was worse after the in-season break in both professional and young players, with no difference between the two. Subjects were sorted into a fast and slow group based on their baseline sprint performance, fast group (FG = <3.95 sec) and slow group (SG = >3.95 sec). A similar split of professional and young players were in each group (FG: 8 professional and 6 young; SG: 9 professional and 10 young). The fast group showed a greater impairment in the RSA best, mean, and total time compared to the slow group.

Practical Takeaways

The major findings showed detrimental changes to RSA performance, but not intermittent endurance performance in both professional and youth players. Furthermore, the best RSA time (i.e. RSA best time) was greatly impaired in the fast group compared to the slow group of players. High-intensity intermittent endurance performance might be more resilient to detraining.

As the infographic link below shows (taken from Vladimir Issurin's Block Periodisation), the residual training effect of the aerobic energy system lasts between 25-35 days while in a detraining period. In contrast, maximal speed starts to detrain much more quickly, ranging between 2-8 days. This would explain the large decreases in RSA best time in both professional and young players after the 2-week Christmas break. A slower RSA best time will generally affect the mean and total time that follows, as maximal sprint speed is considered a main determinant in RSA performance. The 'residual training effect' provides a framework for coaches to prescribe in-season break programmes. During a short break period, such as a 2-week Christmas break, maximal speed should be emphasised. Due to not wanting the players to be training full-time in this period, a few short sessions addressing qualities that detrain quickly or addressing important needs of the athlete for the sport may be the best option. For example, each week could be seen as below:

Maximal Speed Session 1: 2x20m, 1x30m, 1x40m maximal swerve sprint
Maximal Speed Session 2: 3 x Flying 10m

Full Body Hypertrophy Gym:
Single-Leg Lower Knee Dominant
Hip Dominant
Upper Vertical Push
Upper Vertical Pull
Upper Horizontal Push
Upper Horizontal Pull

Want to learn more?
Then check these out...

James's Comments

"The great thing about this paper is the demonstration of Issurin's residual training effects in team-sports. It shows that it may not be necessary to prescribe your athletes with long gruelling aerobic/ glycolytic training sessions during a break period where recovery is often important. Instead, speed is the main quality that needs to be maintained.

Luckily, speed sessions don't need to take long which makes them easy to fit into a schedule for athletes going away with family. With the example above, each speed session may take approximately 12-mins to complete after a warm-up. The full-body gym session can be done in any number of ways and may depend on the athlete you have and the stage of training they are currently in."

Technology & Monitoring

This month's top research on technology and monitoring.

FORCE-VELOCITY-PROFILING AN ATHLETE'S SPEED: HOW MANY TIMING GATES DO WE NEED?
Samonzino, P. et al. (2018) JSCR

REACHING NEW HEIGHTS: HOW TO GET MORE OUT OF YOUR JUMP TESTING
Morin, J. et al. (2018) SportRxiv.

CAN A LOW-COST CRANE SCALE PROVIDE SOLID DATA FOR STRENGTH TESTING?
Urquhart, M.A, et al. (2018) JASCs

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[Abstract]

Force-velocity-profiling an athlete's speed: How many timing gates do we need?

OBJECTIVE

The purpose of this study was to explore what combinations of timing gates would be best for profiling the mechanical outputs of long accelerations. Coaches and teams always want to know more about the speed of their athletes, and finding an ideal placement of timing gates would be practical for both standardisation of profiling and assessment of speed. Therefore, the objective to this study was to assess the construction of timing gate set-up and the impact of statistical confidence that the data could be used for deeper insight.

WHAT THEY DID

The researchers timed athletes with a double-beam system over 40 meters, with timing gates every 5 meters. By collecting data every 5 meters, the researchers could analyse every likely combination of split arrangement to find what is truly necessary to properly assess the velocity curve (See example video **HERE**). After a few runs, all of the athlete's data was analysed with common statically valid approaches to ensure that the practical set-up was scientifically accurate.

WHAT THEY FOUND

Not surprisingly, a straightforward assessment of athletes sprint profile can be done with timing gates at the 10m, 20m, and 30m marks. The researchers concluded that the spacing of the timing gates must cover most of the acceleration zone of the sprint, but early splits of 0-5m may be very limited in use, at least statistically speaking. Finally, the authors also question the need for using 5 timing gates to analysis an athlete's performance.

» **Practical** Takeaways

Previous research suggested that a minimum of 5 split times are required to accurately calculate sprint mechanical outputs. However, based on the findings of this study, it appears that using just 3 timing gates at 10m, 20m, and 30m is sufficient for power-force-velocity profiling athletes. The authors provided a very simple way to test and profile an athlete's speed by reducing the amount of hardware needed (i.e. timing gates). Based on the evidence, using just three timing splits in 40m sprints can estimate potential of maximum speed as well as set-up a training plan to help improve acceleration programing.

Coaches should be aware that while Radar and Lasers are excellent for research and training, those with simple data points of 10m, 20m, and 30m are excellent alternatives for most purposes. In addition to the convenience proposed by the researchers, the acceleration model proposed by them could be used with caution when estimating peak velocity. Many team-sport athletes can be tested with shorter distances because they, in most cases, are unable to hit above 10 m/s and reach their maximal speed before 40m.

Want to learn more?
Then check these out...

Carl's Comments

"I am a big fan of research that helps create pragmatic testing protocols that are clear and easy-to-follow. The key benefit of this research is that it enables strength and conditioning coaches to accurately test athletes with minimal equipment and effort, minimising the headaches of labourious testing.

One concern of mine, however, is the indirect measurement of peak velocity as it's both a skill as well as an athlete talent. Some athletes are able to run faster with a more gradual acceleration pattern as proposed by Warren Young (Read **HERE**), but some coaches may not see the same outcomes. In my experience, both acceleration and peak speed should be tested separately as a few athletes can be coached up to hit 0.3 to 0.8 m/s above what their talent is capable of."

[Abstract]

Reaching new heights: How to get more out of your jump testing

OBJECTIVE
Jump testing is very popular due to its simplicity and the short amount of time needed to perform team assessments. Also, due to the risks perceived by coaches, jump testing is convenient to estimate leg power as it's safe and doesn't need much skill from the athlete. If coaches could evaluate leg power with more validity from jump testing, a protocol could help a lot of teams get more out of their data if they could equate for other variables outside of just the maximal height readings (e.g. power output). Thus, the goal of this study was to help determine an effective way to evaluate leg power with an appropriate mathematical methodology with jump testing.

WHAT THEY DID
Internally, the researchers investigated the modelling of leg power based on jump height and additional measured values. Their first step was to determine the 'limits of positioning' of jump height being a proxy to leg power with mathematical modelling. Second, the sport scientists gathered mathematical evidence of a more granular context-driven model with accessible inputs that coaches could use.

WHAT THEY FOUND
The researchers findings were not shocking. Body mass, leg length, and the inclusion of the best jump height (or similar) using their equation was superior to a single summary measure of jump performance. Based on their past work and other research, an athlete should be appraised by the context of their anatomical attributes (e.g. leg length) to see a "richer" picture of what is going on with their jump tests. Since power is very relative, adding more measures that are simple and easy to do is strongly and rightfully recommended.

Practical Takeaways

Coaches should rethink limiting jump tests to peak height, and since most teams measure an athlete's weight, adding in limb length data is very quick and easy. In the future, every coach should migrate their reporting from just the athlete's name and their peak jump height to using relative equations that incorporate the mass and height of the athletes. This study references all of the necessary equations and the authors have provided an **inexpensive app** and **complimentary spreadsheet** to properly calculate jump performance.

Given the fact that the measures requested by the formula (i.e. mass and limb length) are easily accessible and very quick to collect, using the spreadsheet from the authors or something similar makes estimating leg power very easy and convenient to do in the real-world. In addition to the simplicity of testing vertical jumps, coaches should think about how body mass and shape interact with speed testing horizontally.

Want to learn more?
Then check these out...

Carl's Comments

"Historically, coaches have addressed comparing and extrapolating jump testing for years. However, most of the models were binary body mass and take -off velocity calculations and, therefore, didn't' look at how the jump performance was created. In the USA, much of data collected in the past was simply "jump and reach" (see **HERE**), athlete height and mass, and sometimes position.

With new technology, coaches should add to the existing model by adding more contextual information (see **HERE**), such as data below the knee (e.g. foot function scores) as well as equating for body composition and not just total mass, if possible. One recommendation is to use dorsiflexion testing and squat depth testing in conjunction to mass and height to see how weight training can be refined to individualize the profiling and programming of the athlete."

[Abstract]

Can a low-cost Crane Scale provide solid data for strength testing?

OBJECTIVE
Coaches need to assess strength with a reliable way without letting technical matters and sometimes safety get in the way of maximal efforts. Force plates are extremely useful systems for evaluating numerous sport science endeavours but, unfortunately, cost thousands of dollars. Isometric testing is valid, reliable, and very practical (Great presentation **HERE**) to use in team settings but rigs and racks are sometimes expensive as well. Therefore, a low-cost solution that is easy-to-use and accurate would be of great use for clubs or facilities where budgets are smaller.

WHAT THEY DID
In a short investigation using 8 male subjects, the researchers compared a Force Plate (Kistler) with a commercial grade hand scale that you can buy online for under $200 USD. In order to see if a scale could be used as a replacement to force plates or conventional load cell, they constructed a custom apparatus that could assess an isometric mid-thigh pull with both a Crane Scale and force plates. They set-up the system with a Pull-down bar from York Barbell and integrated the force platform into a custom box that enabled a concurrent measurement. After a few trials of maximal effort isometric mid-thigh pulling, the data was collected and analysed for comparison. The Crane Scale was tested to evaluate the accuracy of loads at incremental points up to 210 kilograms.

WHAT THEY FOUND
Based on the data collected and the statistical breakdown, it appears that a commercial hand scale, particularly the Crane model used, was reliable enough to be used for a crude indicator of isometric strength. The statistical analysis comparing force plate data and crane scale data was strong enough for the authors to conclude that the commercial hand scale solution was acceptable for testing purposes.

Practical Takeaways

While the Crane Scale was inexpensive, the authors recommend comparing it with devices that are known to be accurate or perhaps already validated. Similar to traditional isometric mid-thigh pulls, performing 3-5 trials is recommended with the scale method to extract a better score that properly represents the athlete's ability. In addition to the obvious data calibration to the scale, the system should follow the recent guidelines proposed by the experts in isometric mid-thigh pull testing **HERE**. Having an adjustable chain for various body types is also better than a cable, as it's faster when adjusting length in large group testing environments.

Based on the findings of the research, the authors conclude that this device/setup can be used to accurately perform portable isometric pulling tests. Due to the isometric test being simple and safe, using a crane scale as a portable and inexpensive measure of maximal force is a promising option for coaches/facilities with lower budgets.

Want to learn more?
Then check these out...

Carl's Comments

"Any coach that has a limited budget should see the results of the experiment as an entry point into maximal strength testing.

Something to consider, however, is the sampling rate of a load cell (i.e. 1000 Hz), as the rate of force production is especially important and can't be done with a Crane Scale. Still, the use of a crane scale is great for adjusting band tension with accommodating resistance, and using it for other estimations of force such as sled loads."

Fatigue & Recovery

This month's top research on fatigue and recovery.

BIOCERAMIC GARMENTS: THE FUTURE OF RECOVERY?
Nunes RFH, et al. (2018) Journal of Strength and Conditioning Research.

NEUROMUSCULAR FATIGUE: WHAT IS THE "OPTIMAL" RECOVERY DURATION?
Thomas K, et al. (2018) Medicine & Science in Sports & Exercise.

SIMPLIFYING FATIGUE MONITORING: CAN A SINGLE QUESTION PROVIDE THE ANSWER?
Paul DJ, et al. (2018) International Journal of Physiology and Performance.

[Abstract]

Bioceramic garments: The future of recovery?

OBJECTIVE
Far-infrared emitting ceramic materials (FIR) are widely implemented in the animal world to enhance recovery. Recently, FIR clothing was demonstrated to have a beneficial effect on muscle soreness (DOMS) in professional soccer players. As such, this study aimed to further investigate the effects of FIR on performance, DOMS, and biochemical markers of inflammation and oxidative stress in a sample of elite futsal players.

WHAT THEY DID
20 Brazilian futsal players were divided in a placebo (PLA; n = 10) or FIR pants (GFIR; n = 10). During 2 weeks of pre-season, the players wore either a placebo garment or a FIR garment for approximately 8 hours a day for 5 consecutive nights per week. Measures of performance and biochemical markers were obtained at baseline, after week 1, and also after week 2. On the training days, DOMS was obtained after each morning and afternoon. In addition, session rating of perceived exertion (sRPE) was obtained after each training session. The following markers were measured:

Performance measures: Squat jump (SJ), countermovement jump (CMJ), 5, 10, and 15m sprint (5SPRINT, 10SPRINT, 15SPRINT, respectively).

Biochemical markers: Tumor necrosis factor alpha (TNF-a), interleukin 10 (IL-10), thiobarbituric acid–reactive species (TBARS), carbonyl (CB), superoxide dismutase (SOD), catalase (CAT).

WHAT THEY FOUND
Although no significant differences were observed for performance measures, a small effect favouring GFIR was observed for SJ (likely higher on week 2), CMJ (possibly higher on week 1), and 10SPRINT (likely faster on week 1).

These small changes in performance may be partially justified by the moderate to large beneficial effects observed on DOMS on GFIR in comparison to PLA. Moreover, small effects favouring GFIR were also observed for TNF-a, demonstrating that recovery was enhanced on those athletes wearing GFIR and possibly contributing for the differences observed on performance between groups.

Training strain was significantly greater in PLA than GFIR in week 1, with no significant or meaningful differences being observed in week 2.

Francisco's Comments

I really enjoyed this study as the authors investigated a recovery modality that has not been widely investigated, although it is extensively used in the animal world (e.g. horse recovery). The fact that a placebo group was used, and the athletes were elite athletes exposed to high training loads, reinforces the high quality of this study.

The results from this study demonstrates that GFIR may aid recovery during two weeks of pre-season. My expectation is that if training load was maintained high for another 2 or 3 weeks, the effects of GFIR would be more evident due to likelihood of accumulated fatigue.

A question that I'm force to raise is if the small benefits from the GFIR result from the recovery modality itself or from the differences observed in training loads (i.e. training loads were lower for athletes in the GFIR in week 1)? Or were the loads perceived lower by the athletes as a result of GFIR?

As the athletes were all exposed to the same training regime and all subjects participated in 100% of the training sessions, we can speculate that the athletes' recovery from GFIR was enhanced; meaning that the athletes perceived training loads to be lower.

Further research should look to investigate in more depth the effects of GFIR on the time course of different fatigue measures (e.g. collect fatigue measures 0, 12, 24 and 36 hours after the fatigable exercise). For example, what would be the effect of having FIR in all the garments that are worn by an athlete? The FIR garment range can be extended beyond sleeping pants (e.g. Under Amour's recovery sleepwear range). Furthermore, it would also be very interesting to investigate the effects of compression garments with FIR in recovery.

Want to learn more?
Then check these out...

Practical Takeaways

"Compression garment with far-infrared emitting ceramic materials was demonstrated to aid recovery during a dense futsal training period as demonstrated by the changes in DOMS and serum IL-10 and TNF-a. Ultimately, these changes may have contributed to the differences observed in jumping and sprint performance between the two groups.

The findings from this study suggest that the use of GFIR during sleep may speed-up recovery during congested training periods such as pre-season periods."

[Abstract]

Neuromuscular fatigue: What is the "optimal" recovery duration?

OBJECTIVE
Athletes are frequently exposed to different training methods which specifically target increases in strength, power, and speed. Although differences in protocols are widely described in the literature, less is known about the effects of such training methods on fatigue. This study aimed to understand the differences in neuromuscular fatigue and recovery after heavy resistance, jump, and sprint training.

WHAT THEY DID
Ten male athletes were randomly exposed to three different training protocols:

⇒ Heavy resistance training (RT) – 10 × 5 back squats at 80% 1RM;
⇒ Jump training (JUMP) – 10 x 5 squat jumps;
⇒ Sprint training (SPRINT) – 15 x 30m sprints.

In order to monitor neuromuscular fatigue, measures of neuromuscular fatigue, perceptual fatigue, muscle soreness, and creatine kinase (CK) were obtained before, immediately after, and 24, 48 and 72 hours after the exercise. The rate of perceived exertion (RPE) was also obtained after each training session.

WHAT THEY FOUND
The authors observed differences in the RPE reported by the athletes to RT (RPE = 8), SPRINT (RPE = 6), and JUMP (RPE = 5). In accordance with RPE scores, perceived levels of fatigue were elevated 48 hours after the RT and SPRINT, and 24 hours after the JUMP protocol. Muscle soreness was elevated above baseline levels for all training groups' 48 hours afterwards. Muscle soreness was significantly higher in the RT vs. JUMP (for up to 72 hours) and SPRINT vs. JUMP (for up to 48 hours). CK was elevated in comparison to baseline for up to 24, 48 and 72 hours for RT, JUMP, and SPRINT, respectively. CK was significantly lower at 24 hours in JUMP in comparison to SPRINT and RT. Peripheral fatigue (i.e. twitch force) was elevated for up to 48 hours after each training protocol in comparison to baseline. Central fatigue (i.e. voluntary activation) was present for up to 24 hours after the JUMP and SPRINT protocols and for 48 hours after the RT.

Francisco's Comments

This study investigated a topic where there is a lot of speculation but little research. Central fatigue is widely discussed in strength, power, and sprint training books, and many training methods rely on central fatigue to adjust the weekly training plan.

The findings from this study demonstrate that central fatigue may not be the principal reason for fatigue beyond 24-48 hours after maximal intensity exercise. Moreover, although central fatigue was evident for 24 (JUMP and SPRINT) and 48 hours (RT) after training, the variables measured by the authors to reflect excitability and inhibition of the central nervous system (e.g. electromyographic responses to transcranial magnetic stimulation of the Brodmann area 4) did not changed significantly.

Not surprisingly, athletes recovered faster from the jump training than they did from resistance and sprint training. As mentioned by the authors, it is simply not feasible to equalise the training loads between the different training methods, making it difficult to know how fatiguing each protocol actually was. From my experience, the SPRINT and RT volumes utilised in this study (i.e. 15 reps of 30m and 10 sets of heavy squat) are higher than what I've being using in the real-world for a single session. Nevertheless, the 10 sets of 5 jumps is probably within the normal jumping volume of a power session for a team-sport athlete.

Just like many other coaches, my approach to strength and power training is to prescribe higher loads earlier in the week and lighter loads close to the game day (2 days before the game), and this study supports this practice. You can also find some studies that also support this practice via the links below.

Going back to central fatigue, I would be very interested in understanding the role that of other types of stressors, rather than just training stress, have to play in the development of central fatigue. For example, professional team-sport athletes are often exposed to high-pressure meetings, theoretical sessions, and other psychological stressors such as personal life. As such, I strongly believe that all of these aggressors will have a massive impact on central fatigue.

Want to learn more?
Then check these out...

Practical Takeaways

"This study demonstrates that maximal intensity training methods lead to high levels of neuromuscular fatigue and that 48 to 72 hours of recovery are required in order to fully recover.

Peripheral fatigue was shown to last for a longer period of time than central fatigue. It is, therefore, likely that central fatigue itself is not the main reason for a decrease in performance from maximal effort training.

From a training prescription perspective, these findings support the need for a 48 -72 hour recovery interval between training sessions when targeting maximal efforts. Putting these findings into practical training guidelines, for high loads (e.g. resistance training, sled/ prowler sprints, etc.) and sprint training, 72 hours of recovery are recommended. For jump training with low additional load, 48 hours of recovery time is recommended."

[Abstract]

Simplifying fatigue monitoring: Can a single question provide the answer?

OBJECTIVE
Many different methods are frequently used in order to monitor an athlete's fatigue and readiness. Due to time and money constraints, subjective recovery scales are the most implemented method to monitor fatigue in an applied setting. The aim of this study was to investigate the reproducibility and sensitivity of a single-question subjective tool to monitor fatigue levels after an international youth football match.

WHAT THEY DID
Perceived recovery was collected from 20 young, trained football athletes (16 years old) before and after an international match using the perceived recovery scale (PRS). The PRS consists of a 1-10 Likert scale where 0 represents a low score (very poorly recovered/extremely tired) and 10 a high score (very well recovered/highly energetic).

Data was collected 2 times before the match and 3 times after the match:
⇒ 2 hours before the match
⇒ 30 mins before the match
⇒ 15 mins after the match
⇒ 3 hours after the match
⇒ 24 hours after the match

Comparisons were made between a group of players that played for 45 min (HT; n = 9) and a group that played for 90 min (FT; n = 11). Furthermore, the scores obtained 2 hours and 30 mins before the match were used to test the reliability of PRS.

WHAT THEY FOUND

A high reproducibility was reported by the authors as the scores obtained 2 hours and 30 mins before the match were similar (6.9 vs 7.1 for 2 hours and 30 mins, respectively). No differences between groups (HT and FT) were observed for scores obtained before and after the match. Lower scores were observed 3 hours after the game in comparison to scores before the match, and 15 mins after the game in comparison to 24 hours after the game.

Francisco's Comments

For me, two main conclusions need to be highlighted from this study findings:

1) The PRS is a reliable scale to track recovery

2) The responses to a match are very individual

The fact that the responses were very individual demonstrate the need for different recovery and training approaches when athletes are expected to perform within a short period of time.

Athletes reported to feel recovered 24 hours after the match. At higher levels of practice (i.e. professional senior football), an increase in perceived fatigue can be expected for 48-72 hours after a game. I think it would be very interesting to study the differences in PRS in athletes who play a higher level of football and those from other sports.

The individualisation of recovery protocols and subsequent training sessions according to the athlete's level of perceived recovery and/or the session training load is now somewhat common practice. Although this process is vulgarly performed in an informal way, practitioners can rely on subjective scales like the PRS to help them making that decision. For example, a more intense recovery protocol can be set for athletes who have a PRS score of lower than 3 when taken 2 hours after a training session. A very simple example is provided in the attached image below.

It is important to mention that although a previous study has demonstrated that the PRS exhibit a moderate relationship with objective markers (i.e. sprint performance) in laboratory setting, the current study did not collect any objective markers of fatigue. Therefore, the validity of the PRS to monitor recovery in the applied setting is still to be demonstrated.

Want to learn more?
Then check these out...

Practical Takeaways

"The findings from this study demonstrate that PRS is a tool that can be used to accurately monitor an individual's recovery status. The fact that PRS is cost-free, time efficient, and non-invasive makes it very useful when dealing with a large groups of athletes.

Given that the PRS scoring system is similar to the rate of perceived exertion scale (RPE; 0 to 10), if players are familiar with RPE, it allows familiarity with the PRS. See the attached images below for the PRS and intervention-based recovery strategies based on the athlete's response.

Fatigue was evident after the match (i.e. lower PRS scores 15 mins and 3 hours after the game) but not 24 hours after, demonstrating that 24 hours might be sufficient for youth soccer athletes to recovery from a football game.

Although unexpected, no differences were reported between the 45-min and 90-min playing groups for the PRS. Nevertheless, a large individual variation was observed. These findings reinforce the need to collect data individually and provides important information to practitioners on the individualisation of recovery techniques."

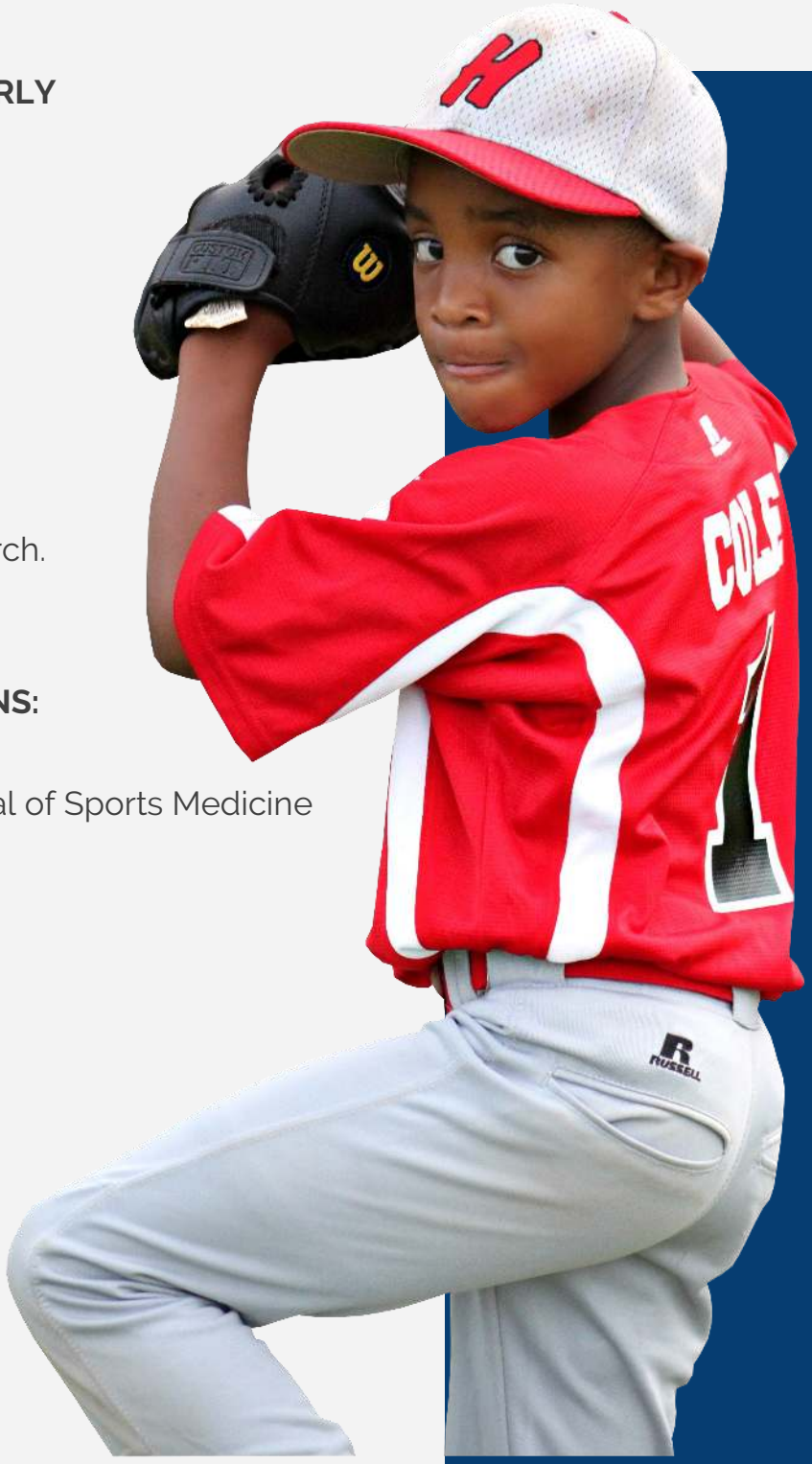
Youth Development

This month's top research on youth development.

FINDING THEM EARLY: DOES EARLY RECRUITMENT CREATE FUTURE SUPERSTARS?
Hertzog, M. et al. (2018) Sports.

GRIP STRENGTH, HEALTH, AND PERFORMANCE: IS THERE A RELATIONSHIP?
Toong, T. et al. (2018) Journal of Strength and Conditioning Research.

SINGLE VS. DOUBLE WEEKLY PLYOMETRIC TRAINING SESSIONS: WHICH IS MORE EFFECTIVE?
Bianchi, M. et al. (2018) The Journal of Sports Medicine and Physical Fitness.



[Abstract]

Finding them early: Does early recruitment create future superstars?

OBJECTIVE
Traditionally, talent identification schemes have selected individuals based on a certain skillset or physical disposition built around a preconceived image of what makes an "elite" athlete. To find new talent, early recruitment may be preferred, with recent research showing a higher rate of physical development when players train at an academy compared to non-academy soccer players. Therefore, the aim of this study is to identify the effects of a 2-year training period (from 16-18) on neuromuscular and endurance performance in academy soccer players.

WHAT THEY DID
This study looked at two groups:

1) Early recruitment (n = 16) – defined as those training in the academy since the ages of U14-15's.
2) Late recruitment (n = 21) – defined as those who have only been at the academy since U16.

Both groups involved in the study performed a squat jump, a countermovement jump (CMJ), a countermovement jump without arms (CMJwA), 10-m sprint time, and an aerobic Vam-Eval test (MAV) in the football pre-season.

WHAT THEY FOUND
In the Vam-Eval aerobic test, 10m sprint, CMB, CMJwA, it was found that early recruitment did not produce any greater training adaptations when compared to those who were late to the soccer academy. These finding were consistent with other studies, reinforcing that this may be a consistent theme across soccer (Football) academies in the UK.

Practical Takeaways

This study found no interaction between time in an academy and physical output. Searching for characteristics of elite performers can be a great way of finding new talent in sport. An example of this can be seen in the attached video, where in 2016, UK sport began to search for men who were 6'3 or more and women who were 5'11. These physical traits were commonly seen in high-level rowers, so naturally pursuing these attributes could find some hidden athletic gems. In football, the same could be achieved with regular events or development programmes, where coaches spend time with those who are older than the typical academy invite age. More specifically, coaches could design days that pursue the philosophy of the club.

For example, academies that identify with an attacking style of play may design sessions that require high levels of repeatability and speed by applying varied distances and constraints (i.e. zonal or overload phases). Through this, they may find players who are suited to the demands and ethos of the club, where true game-skills and cross-educational ability is revealed. As a result, this information may be very useful for you if you're involved the talent identification process or are at least looking to get involved.

Want to learn more?
Then check these out...

Tom's Comments

"Talent identification and development schemes are vital when looking to supply the senior team with new players, who bring with them exciting ideas and playing styles. Visually tracking performance outputs (strength, power, speed etc.) may be relatively easy to identify within youth due to the large inter-individual differences, where maturation and previous coaching can present clear and visible differences. However, the real art of talent development is spotting a blend of tactical, technical, physical, and emotional skills that can contribute to long-term performance. John O'Sullivan discusses this in great detail (see podcast linked below) and makes a notable effort to explain the difference between spotting current talent, and identifying long-term athletes who can develop as both an individual and member of a team.

This study found no interaction between time in an academy and physical output. In some respects, this is promising for those who are late to enter a high-performance environment, offering hope for those that are new and have missed previous coaching. Some great examples can be seen in the attached article titled "Top 15 late bloomers". In this article, some of the best sporting talent in their respective fields have been highlighted for entering their sport late, but still achieving great success. This supports the idea of searching for talent far after maturation, where many players can slip through the net during youth but should not be discounted, especially when there may be no benefit to training in an academy."

[Abstract]

Grip strength, health, and performance: Is there a relationship?

OBJECTIVE
Muscular strength and grip strength have been closely associated with a reduced risk of cancer, cardiovascular disease, and mortality. To use grip strength scores as a method to baseline individuals or assess performance, a reference population must be used to see if a group are below, similar, or above average for their age, ability, gender etc. To date, only a few studies exist which provide such norms, creating a gap that this research aims to fill. In addition, this study explored the relationship between age, sex, body mass, and playing level on grip strength and performance.

WHAT THEY DID
690 male and female youth ice hockey players between the ages of 10-16 years were included in this study. All of these participants were asked to squeeze a hand-held dynamometer maximally for 3-seconds and were given 3 trials on both their dominant and non-dominant hand with a 10-second rest between reps. The dynamometer was adjusted for hand size. Meanwhile, hand dominance was established by asking the participants which hand they preferred to write with. All participants were given verbal encouragement to complete the test with maximal effort.

WHAT THEY FOUND
Until the age of 12, males and females both presented similar grip strength results. However, after this point, males had greater strength which also correlated with body size (i.e. the heavier they were, the stronger the grip). For the non-dominant hand, competitive players had far greater grip strength (26.1 6 ± 7.3 kg) than those competing in 'house' sport (23.26 ± 8.3kg). The results of this study also indicates a greater improvement in grip strength with age, where children move from 18.3 ± 3.4kg of grip strength (boys aged 10, dominant), to 42.0 ± 8.6 by the age of 16. This trend was similar in females.

Practical Takeaways

Hopefully, the importance of grip strength and measuring grip strength can be seen given the relationship to health and muscular strength. Some considerations for exercises may include both normal and thick-bar variations of deadlifts, farmer's walks, or hanging drills. These are all great forearm/grip builders, but the attached video may add something a little bit different to your programming which may be more applicable to those with a low training age.

Other measures that have previously been investigated include bone mineral density and overall health, both of which can be a great way of assessing your athlete's health in a relatively simple and affordable manner. In the attached article titled 'Grip strength, body composition, and mortality', some of these facts are discussed in greater detail and can be used as a resource for your athletes moving forward.

Want to learn more?
Then check these out...

Tom's Comments

"When working with large groups of youths, the time it takes to complete a test can be a decisive factor in its inclusion. Tests that take a long time to complete or can only be performed by one participant at a time can leave some of the group unsupervised and poor behaviour can quickly become an issue. Although this test is "maximal" in effort, it can be performed during break/rest periods (i.e. in between an agility test rep), allowing the coach to use their time efficiently as a behaviour management strategy in such periods. However, these should still be performed correctly with standardisation etc.

When combined with other measures, grip strength can allow you to see how effective your training is by assessing extensor/flexor forearm strength, which is important in many sports. This has been echoed in the attached podcast, where Laurence Griffiths discusses how rock climbers spend a lot of their time developing grip strength when they are not climbing. As a S&C coach, I would personally consider rock climbing to be one of the greatest grip builders out of many sports. The fact that climbers pursue additional grip work away from their main sport demonstrates how important this is to their performance, and furthermore, how we may under-programme grip-based exercises for other athletes (e.g. rugby players). This may be of particular importance during maturation, where the bones of the forearm undergo remodelling and will require high levels of strength and coordination to avoid injury."

[Abstract]

Single vs. double weekly plyometric training sessions: Which is more effective?

OBJECTIVE
To progress as a football player, training must be continuously challenging and developmental in a physical, tactical, technical, and emotional capacity. The quantity of training per week can be a decisive factor in this, so long as it is progressive and purposeful to prevent overuse injuries. Plyometric training has grown in popularity, acting as a performance enhancing initiative that progresses the stretch-shortening cycle. However, few studies have looked into the effects of quantity on performance. This study aims to compare the implementation of a single vs. double plyometric session, measuring its effectiveness on jump, sprint, and change of direction ability.

WHAT THEY DID
23 young football players (mean ± SD; age 17 ± 0.8 years, weight 70.1 ± 6.4 kg, height 177.4 ± 6.2 cm) were included in this 8-week study. These were randomly assigned based on a computer-generated sequence, who were then allocated to either a low or high plyometric training group. Before the intervention, all participants completed a long-jump, a single-leg triple hop distance test (SLTH) [See attached video], and a triple hop distance jump. To evaluate sprint speed, timing gates measured speed at 10, 30, and 40m. Change of direction (COD) was measured by the 505 COD Test. Both groups completed the following programme: 4x5 drop jumps from 60cm followed by a subsequent jump over two 15cm heights, 4x6 horizontal jumps, and 4x6 jumps over obstacles of 15cm. These were completed once in the low-volume group and twice in the high-volume group.

WHAT THEY FOUND
At the end of the intervention, both the high- and low-training intervention groups showed positive effects in all tests apart from the low-volume group in the 505-COD test. This study shows that both plyometric interventions were beneficial at developing speed and agility. However, no intervention (high vs. low) was "better" than the other over an 8-week period.

Practical Takeaways

In this study, it has been demonstrated that performing both a high- and low-volume jump-based intervention produced no measurable differences in performance outcomes (long jump, SLTH, and triple hop distance jump). The authors recommend that using a low plyometric volume (equivalent to 80-100 jumps a week) may be beneficial in the pre-season. These recommendations may, however, not be applicable to those who have a low (i.e. too hard), or high (i.e. non-developmental) training age. With these considerations in mind, the use of hurdles, training bags, or balls may add height to jumps and, therefore, additional "load" to a jump. This takes away from the idea of ever-increasing volume, and moving on to more intense exercises to develop reactive ability and improve force tolerance.

To improve the reliability of the 505 COD test (see description of test **HERE**), Dr. Sophia Nimphius has suggested that being fast over 10m may hide poor change of direction ability as the individual can cover space in a shorter time. In the same test but with a slower individual, their change of direction speed may actually be greater, but their acceleration out of a low position may be lacking. It could, therefore, be argued that their 'change of direction' is not truly measured. In the attached podcast, a concept known as the 'COD deficit' has been introduced, which in brief compares the additional time taken to change direction against a pure linear sprint over the same distance. This is a more 'realistic' measure of COD ability and could be used as a valid way of getting around this issue.

Want to learn more?
Then check these out...

Tom's Comments

"This study has left us with a good selection of exercises that could be used at the end of a warm-up during the 'potentiation phase' and can now be justified with supporting literature. I would always encourage caution when asking youth to jump from heights of 60cm, as this height may prove too much for those with a low training age. Off the back of this, I would advise that you alter the height based on previous experience and landing quality. A great method for assessing their landing abilities has been offered by **Padua et al. (2015)**, who identifies a scoring criterion known as the 'Landing Error Score System' (LESS). This can be used to inform decisions regarding jump quality. To learn everything you need to about the LESS and how it is graded, check out our Science for Sport article on the LESS test by **clicking HERE.**

In future studies, I would like to see the volume increase so that practitioners can understand how many sessions past one are needed to improve performance. During the pre-season, coaches may have the pleasure of using three or four sessions a week to develop explosive properties. However, during the season, this may not be possible. In addition, if one session can develop the same properties as two, three, or even four sessions a week, then it may be advantageous to spend this time developing other qualities such as strength or speed in addition to plyometric abilities."

Nutrition

This month's top research on nutrition.

ARE EXERCISE PROFESSIONALS FIT TO PROVIDE NUTRITION ADVICE?
Mitchell, L. et al. (2018) Journal of Science and Medicine in Sport.

AFTER EXERCISE, WHAT IS THE BEST TIME TO CONSUME PROTEIN TO HELP WITH RECOVERY?
Sollie, O. et al. (2018) Journal of Applied Physiology.

SHOULD FOOTBALLERS CONSUME PROTEIN RIGHT BEFORE SLEEP?
Abbott, W. et al. (2018) International Journal of Sports Physiology and Performance.

[Abstract]

Are exercise professionals fit to provide nutrition advice?

OBJECTIVE
Registered Exercise Professionals (REPs) are trained to address structured exercise guidelines to healthy individuals. However, in addition to exercise, REPs provide nutrition advice across fitness and medical issues, which is beyond their scope of practice. Although REPs may be confident in their ability to provide nutrition advice, little is currently known about their competency. Therefore, the aim of the study was to examine the level of general nutrition knowledge of REPs and compare this to a sample of community members (CTM) and university-trained dietitians (DN).

WHAT THEY DID
A convenience sample of REPs, the Australian CTM and DN were recruited through social media platforms, flyers and newsletters.

Individual nutrition knowledge was evaluated using a revised version of the General Nutrition Knowledge Questionnaire (GNKQ) to better suit the Australian population. Total nutritional knowledge score and section scores were compared between the three groups (REP versus CTM and DN).

WHAT THEY FOUND
A total of 554 participants completed the questionnaire (REPs = 161, CTM = 357, and DN = 36). As expected, the DN group had the highest level of nutrition knowledge both overall and in each of the four sections in the questionnaire.

Although REPs had a higher level of nutrition knowledge than an age-matched CTM sample in areas related to nutrient content of foods, they scored similarly to CTM for knowledge of dietary guidelines, making healthier food choices, and diet-disease relationships.

Practical Takeaways

From a practical standpoint, REPs and the general community showed similar diet-disease knowledge and, as such, this raises concerns over the competency of REPs to provide nutritional support to those with medical conditions and clearly violates potential scope of practice. With this in mind, Mitchell and colleagues suggest that REPs should collaborate with qualified health professionals, including qualified dieticians, to ensure correct health and body composition related goals of clients can be delivered via a safe and evidence-based manner.

Accordingly, the take home messages from this study are:

1) Reps showed greater total nutrition knowledge than general community members, although their knowledge on diet-disease relationships was no better than the general community. This is supported by 40% of those asked in the study (see link below), admitting that they perform no further nutrition-related reading.

2) As such, providing nutrition advice beyond general healthy eating may pose potential harm to clients with medical conditions and leaves REPs legally vulnerable.

3) REPs should be encouraged to refer clients to qualified dietitians for specialised nutrition support, given dietitians competency for the provision of medical nutrition therapy.

Want to learn more?
Then check these out...

James's Comments

"Despite the study highlighting a relevant and important problem in the fitness and health industry, issues regarding bias existed in this study.

First, the sample size of REPs recruited in the study was moderate, and only represents a small percentage of REP's within Australia as a whole. Subsequently, the risk for sampling bias cannot be excluded. In addition, there were large differences in sample sizes between the groups, with more females across all groups. A final limitation was the time difference between data collection from the CTM and DN groups, which could have provided an additional error in collection of information.

In summary, caution should be taken when receiving nutritional advice from those who are not qualified. This has been recently discussed by the same group of authors with another paper which is linked below alongside a nice video (also linked below). Both the video and study determines if REPs are working within their scope of practice and if their qualifications align correctly, specifically within those factors that relate to the delivering of nutrition advice. I have also added link 3 below which shows the limited amount of advice provided by REP's from the online magazine they provide."

[Abstract]

After exercise, what is the best time to consume protein to help with recovery?

OBJECTIVE
Ingestion of carbohydrate and protein after endurance exercise has emerged as a key nutrition practice for many cyclists. Ingestion of both has been reported to be better than only carbohydrate to stimulate the rate of glycogen synthesis (increase in energy) and increase the rate of protein synthesis (increase in muscle recovery). The aim of this study was to investigate the effect of protein and carbohydrate consumption during early recovery from exhaustive exercise.

WHAT THEY DID
Eight male elite endurance cyclists completed two experimental interventions in a double-blinded randomised crossover design. Both interventions, were separated by at least six days. During the first two hours of recovery, participants ingested either 1.2g per kg per hour of iso-energetic carbohydrate supplementation (CHO only) or 0.8g carbohydrate + 0.4g whey protein supplementation per kg per hour (CHO+ PRO). Nutritional intake during the remaining recovery period was similar between interventions and adjusted to body weight. After an 18-hour recovery period cycling performance was assessed with 10-seconds sprints, 30-minutes of cycling 73% of VO2max (maximal output), and a cycling time-trial (TT).

WHAT THEY FOUND
The TT was 8.5% (3.5 min) faster after CHO+PRO compared to CHO alone. Mean power output during the sprints was 3.7% higher in CHO+PRO compared to CHO alone. Consequently, TT and sprint performances were improved 18 hours after exhaustive cycling by co-ingestion of protein and carbohydrate supplementation during the first two hours of recovery.

Practical Takeaways

Supplementation with CHO+PRO (carbs and protein) within the first few hours after exhaustive cycling improves cycling TT and sprint performance the following day. Similar interventions are used with the elite cyclists at Team Sky which is shown in a video below (Link 1). Their diets are also shown in the infographic link below along with an in-depth discussion by Professor James Morton in the podcast.

Practically, this finding is applicable to elite endurance performance during competitions over consecutive days who train and compete with limited time to recover. In cycling events, where prolonged high intensity endurance exercise is performed, exhaustion and fatigue develop quickly. As a result, effective nutritional recovery strategies are therefore crucial in these multi-day races.

Considering this, it is better for athletes to co-ingest CHO+PRO rather than CHO alone during the first two hours of recovery to stimulate enhanced recovery and effective exercise capacity the following day. Nevertheless, there are other important factors to be considered for effective post-exercise recovery and exercise capacity for the cyclist, including optimal rehydration. A milk-based carbohydrate-protein mixture may, therefore, be a beneficial supplement to consume under these circumstances for rehydration, muscle glycogen restoration (energy), and optimal exercise capacity following short recovery (see link #2 below).

Want to learn more?
Then check these out...

James's Comments

"The authors should be credited by designing a double-blinded randomised crossover study using participants who were experienced elite cyclists (VO2max 74.0±1.6 ml-1kg-1min-1) and adhered to standardised diet and training prior to the two experimental interventions, presenting a well-controlled study.

However, the lack of muscle biopsies can be considered as a limitation in the study since data on glycogen concentrations and mitochondrial function would have been valuable information to help explain the differences in recovery performance. For example, participants starting levels of muscle glycogen may have been very different, but without biopsies data this remains speculative.

Furthermore, this study used a small sample size (n = 8), resulting in low statistical power on some measured variables and so future work should now look to repeat this in greater numbers."

[Abstract]

Should footballers consume protein right before sleep?

OBJECTIVE

It has been reported that many soccer players often suffer from prolonged decrements in muscle function following matches. Not only is strength, power, and sprint performance affected but complaints of muscle soreness and psychometric disturbances are also often reported. The majority of studies assessing the effects of immediate protein feeding on aforementioned variables are typically performed in the morning. Such studies have not been translated to scenarios when exercise is performed in the evening and the time for additional protein ingestion is limited. Therefore, this study aimed to assess whether consuming casein protein before sleep would accelerate acute functional recovery after a night-time soccer game in professional players.

WHAT THEY DID

Ten young male soccer players (19 years old) from an under-23 and reserve squad playing in the English Premier League took part in the current study. The study utilised a randomised, single-blinded placebo crossover design in which participants consumed a casein protein (CP), a slow-release protein supplement, or a carbohydrate supplement (CON) 30-minutes before going to bed after a soccer match (kick-off at 19.00). Countermovement, reactive strength index, self-reported muscle soreness, and the adapted Brief Assessment of Mood Questionnaire were measured 12, 36, and 60 hours after each match to assess recovery. The players' habitual diet was not altered but they did keep a 3-day food diary to record dietary intake.

WHAT THEY FOUND

The main finding of this study was that 40g of casein protein consumed before sleep enhanced muscle function recovery in the 36 hours following a soccer match played at night. Specifically, countermovement jump height and reactive strength index were restored to pre-match values more rapidly when CP was consumed as opposed to a carbohydrate.

Practical Takeaways

From a practical perspective, the findings suggest that professional soccer players can accelerate functional recovery by consuming 40g of casein protein after evening matches. This is especially interesting given that league and cup matches are often played at night (19:45 – 20:05 kick-off) and, as such, night games can limit the recovery "window" before bed.

This study suggests that a protein-rich meal following a night match may not be sufficient to optimise recovery following a late soccer match and, therefore, players should be encouraged to consume an additional bolus of protein before bed to enhance total protein intake following a night match and enhance functional recovery.

With this in mind, it is crucial that players:

1) Avoid consuming any caffeinated drinks (e.g. coffee or cola) before sleep.

2) Consume a protein-rich meal following the game to maximise the rate of muscle protein building.

3) Consume a protein source rich in casein (slow-release protein) before bedtime.

A similar strategy is depicted in the infographic linked below.

For more guidelines on practical nutritional recovery strategies in professional soccer players with limited time between matches, see the study by Ranchordas et al. (2017) also linked below.

Want to learn more?
Then check these out...

James's Comments

"Although additional casein protein before sleep can accelerate the processes required to restore muscle function, the precise mechanisms remain to be clarified. The use of muscle biopsy samples from the players would have confirmed the aforementioned mechanisms.

Although the athletes were professional, the study was performed on a small sample size from one club. Future work should now be extrapolated out into more players from more than one club.

To wrap this study up nicely, for those players that do not want to consume a casein supplement per se, a simple strategy of consuming a glass of milk (80% casein, 20% whey protein) before bed would be a sensible suggestion. Similar strategies are discussed in the podcast linked below with Joseph Agu."

Injury Prevention & Rehab

This month's top research on injury prevention and rehabilitation.

IS STRENGTH TRAINING OUR BEST MEANS OF REDUCING INJURY RISK?

Lauersen JB. et al. (2018) Br J Sports Med.

CHANGES IN THE TENDON: ADAPTATION OR PATHOLOGY?

Hagan KL. et al. (2018) J Appl Physiol.

PATELLOFEMORAL PAIN: TAKING A SECOND LOOK AT THE PROPOSED RISKS

Neal B.S. et al. (2018) Br J Sports Med.

[Abstract]

Is strength training our best means of reducing injury risk?

OBJECTIVE
The wide array of conclusions drawn regarding the effectiveness and accessibility of injury prevention programmes can sometimes be overwhelming. Their foci range from strengthening, proprioception, stretching, and multicomponent interventions. This review looked to qualitatively and quantitatively analyse randomised controlled trials (RCT's) of strength training-based injury prevention programmes, and to present evidence-based recommendations for athletes, coaches, and future research.

WHAT THEY DID
A very detailed and standardised protocol for the review of select databases (PubMed, Embase, Web of Science, and SPORT-Discus) was carried out for articles published between 2012-2017. Two reviewers evaluated all titles and texts, determined risk of bias, and extracted qualitative data. To determine the strength of the results, the authors performed sub-group analyses of age groups, blinding, intervention type, and outcomes along with a meta-regression on the study quality as a whole.

WHAT THEY FOUND
Six studies were included in the final analysis, across which a variety of athletes participated, including elite adults, elite youths, amateur males, adolescent females, and military recruits. Increasing weekly volumes of strength training was the main intervention across studies, with one including a multi-modal approach of balance, core stability, and knee alignment. All studies were of high quality and had low risk of bias.

The dose-response analysis revealed that increasing volume and intensity of strength training correlated significantly with injury prevention: a 10% increase in repetitions per week was associated with a 13% risk reduction. Overall, strength training programmes reduced sports injuries by an average of 66%.

Practical Takeaways

Not only did these strength training programmes significantly reduce sports injuries and more than half the risk of injury, but 4 of the 6 studies reported no adverse effects among their total of 3,991 participants throughout the process (average 8 months of intervention).

Based on the results of this study, the authors made several strength training recommendations for coaches and clinicians. They recommend the following: a familiarisation phase with focus on technique before beginning the gradual increase in volume and intensity; working towards training failure thresholds; ensuring good technique and psychological preparedness to prevent acute injuries; ensuring progressive tissue conditioning and training variation to prevent overuse injuries; and include off-season and/or less demanding periods or phases (see link for infographic below).

They also mention that children do not warrant a significantly different approach, but do suggest that supervision, short-term periodisation, long-term variation, individualised %RM loading and appropriate rest periods be included and monitored in this population.

Want to learn more?
Then check these out...

Steph's Comments

"This review is a breath of fresh air, in my opinion, and for two main reasons. First, it quiets some of the noise surrounding injury prevention programmes and provides solid evidence that we should spend less time worrying about what types of balance and proprioceptive drills we should include and more about how we can effectively implement a progressive, heavy strengthening programme to ensure the athletes have the muscular strength and endurance to readily handle the demands of sport. This is not to say that there is no place in said programme for proprioceptive and neuromuscular training. This is simply to highlight that strengthening should be the overarching focus.

Second, it quells some of the hesitancy around heavier loading in athletes in general. I think, especially in physiotherapy and rehab, that we tend to underload patients. This is not always an issue for a return-to-function, but it can absolutely be an issue for a return to high-level sport. Athletes returning to high-level sport need to be stressed appropriately in order to tolerate the physical and mental requirements of the game, to dominate in those settings and reduce risk of injury all the same."

[Abstract]

Changes in the tendon: Adaptation or pathology?

OBJECTIVE
Tendinopathy, particularly of the Achilles, is considerably more common in runners than in their peers. Ultrasound (US) has been used in the past to measure the thickness, organisation, and echogenicity (amount that a structure reflects the US waves), where greater thickness, less organisation, and lower echogenicity are indicative of tendon pathology. This study prospectively examined Achilles and patellar tendon structure (via ultrasound imaging) in competitive collegiate runners across consecutive sport seasons.

WHAT THEY DID
Participants were 22 collegiate cross country runners and 11 healthy matched controls, all of whom remained in training throughout the 3 competitive seasons and had no prior signs of tendinopathy. Ultrasound images and self-report measures (VISA-A) were collected at three points: one week prior to the start of cross country practise (S1), one week after the end of the cross country season (S2), and one week prior to the outdoor track and field championships (S3). See link below for VISA-A PDF.

US images were graded by a sports medicine physician who was blinded to subject data. The following areas were graded: tendon structure, neovascularisation, and collagen fibre alignment (via circular standard deviation-CSD). The higher the CSD, the less organised the alignment.

WHAT THEY FOUND
Runners demonstrated less organised Achilles tendon alignment and greater thickness compared to controls. Patellar tendon structure did not differ between runners and controls during the seasons, but at the end of the third season, runners demonstrated greater collagen alignment, increased thickness, and increased echogenicity compared to controls. No significant changes in VISA-A were noted, and no cases of patellar or Achilles tendinopathy arose throughout the study. Overall, the authors concluded that Achilles and patellar tendons respond differently to high-volume running and to transitions from one sport to another.

Practical Takeaways

Based on these results, the authors believe that tendons habituate to sport-specific loading, via decreased collagen alignment and echogenicity, and that this is likely an adaptation to reduce the risk of overuse injuries in experienced distance runners. Previous research in novice runners has shown that this tendon habituation and remodelling does not happen in a low-volume programme (34 weeks). This is an important concept, as it demonstrates why tendinopathy rehab or management, particularly in those newer to running, can be a bit longer of a process - these adaptations take time. Being able to confidently share this knowledge with your athletes or clients is critical in establishing proper expectations and short- and long-term goals.

It is also important to note some weaknesses of this study. This study included a small sample size of all collegiate level, otherwise healthy athletes and controls, making it difficult to extrapolate the results to the general population. Though this study design included blinding and attempted to control for bias, it did not take into consideration many confounding factors including, stress levels, sleep, nutrition, overall training age, etc.

Altogether, this study demonstrated clear and convincing support of the types of changes that occur in the highly loaded tendons of experienced runners and how these changes may very well be adaptive vs. pathological.

Want to learn more?
Then check these out...

Steph's Comments

"I admire how this study was able to give merit to the biomechanical influence of tendon loading, while recognising that tissue changes do not often correlate well with symptoms. These athletes, though young, healthy, and experienced, underwent prolonged, high loads over the course of 3 seasons, and not one developed symptoms. We may want to rethink how we interpret imaging results of "damaged tendons" now that we know many alignment and thickness changes that have historically been associated with pathology also occur in experienced, asymptomatic runners (see link to infographic and podcast below).

I think that this information is powerful for coaches and clinicians to know and to be able to explain, as it can be extremely helpful in reassuring an athlete or patient who thinks they are unable to load the area or get back to sport due to such results on imaging."

[Abstract]

Patellofemoral pain: Taking a second look at the proposed risks

OBJECTIVE
Patellofemoral pain (PFP) is common in the general population, with a prevalence of 22.7%. Despite its commonality, there is a lack of evidence investigating the factors associated with the development of PFP across different populations. The 3 main objectives of this study were as follows: 1) to establish prospective links between all investigated variables and future PFP; 2) to identify risk factors and PFP incidence specific to individual homogenous cohorts; and 3) to inform future studies on PFP prevention.

WHAT THEY DID
A literature search and meta-analysis was performed using MEDLINE, Web of Science, and SCOPUS from inception until February 2017. Study quality was assessed using the Newcastle-Ottawa Scale (NOS) (see link below for description). Data related to study characteristics and analysis of these data were performed by 2 different reviewers. A third reviewer extracted data regarding potential risk factors to be included in the meta-analysis. The authors pooled the final data and compiled results for a heterogenous PFP group as well as several homogenous subgroups where possible (military recruits, adolescents, recreational runners).

WHAT THEY FOUND
All of the following factors were found not to increase the risk of PFP: sex, height, weight, BMI, age, limb length, lower-limb alignment (Q angle).

Decreased quadriceps strength in adult military recruits and higher hip abduction strength in adolescents were the only significant risk factors associated with developing future PFP. This is interesting, as much of the previous research has identified decreased hip abduction strength, particularly in females, to be a risk factor for increased PF forces and potential PFP (**HERE** and **HERE**). The authors acknowledged that their findings may be associated with increased activity levels in the adolescent age groups as well.

Practical Takeaways

These findings, therefore, can help direct training and treatment strategies depending on age and demographics, including which interventions can be focused less on (i.e. less on quadriceps strength in adolescents). According to what these authors concluded, it would perhaps be more beneficial to focus on training movement patterns, proprioception, and neuromuscular control in adolescents, and to focus on quadriceps strengthening in adults. This is contrasting to some previous evidence, though it does offer a means of "prioritising" prehab, training, and rehab where necessary.

What was very clear, was the positive impact of education and a load management plan for these individuals and particularly in the adolescent population. Considering the merging evidence regarding the psychosocial variables of anxiety, depression, catastrophising and fear avoidance, proper education and an individualised, supportive plan is essential (training or rehab).

Lastly, the authors make a strong point that with such inconsistency in the literature, and the lack of success with attempting to establish a "true cause", future studies "should be designed to investigate the interactions between a 'web of determinants' that are likely to be non-linear in nature."

Want to learn more?
Then check these out...

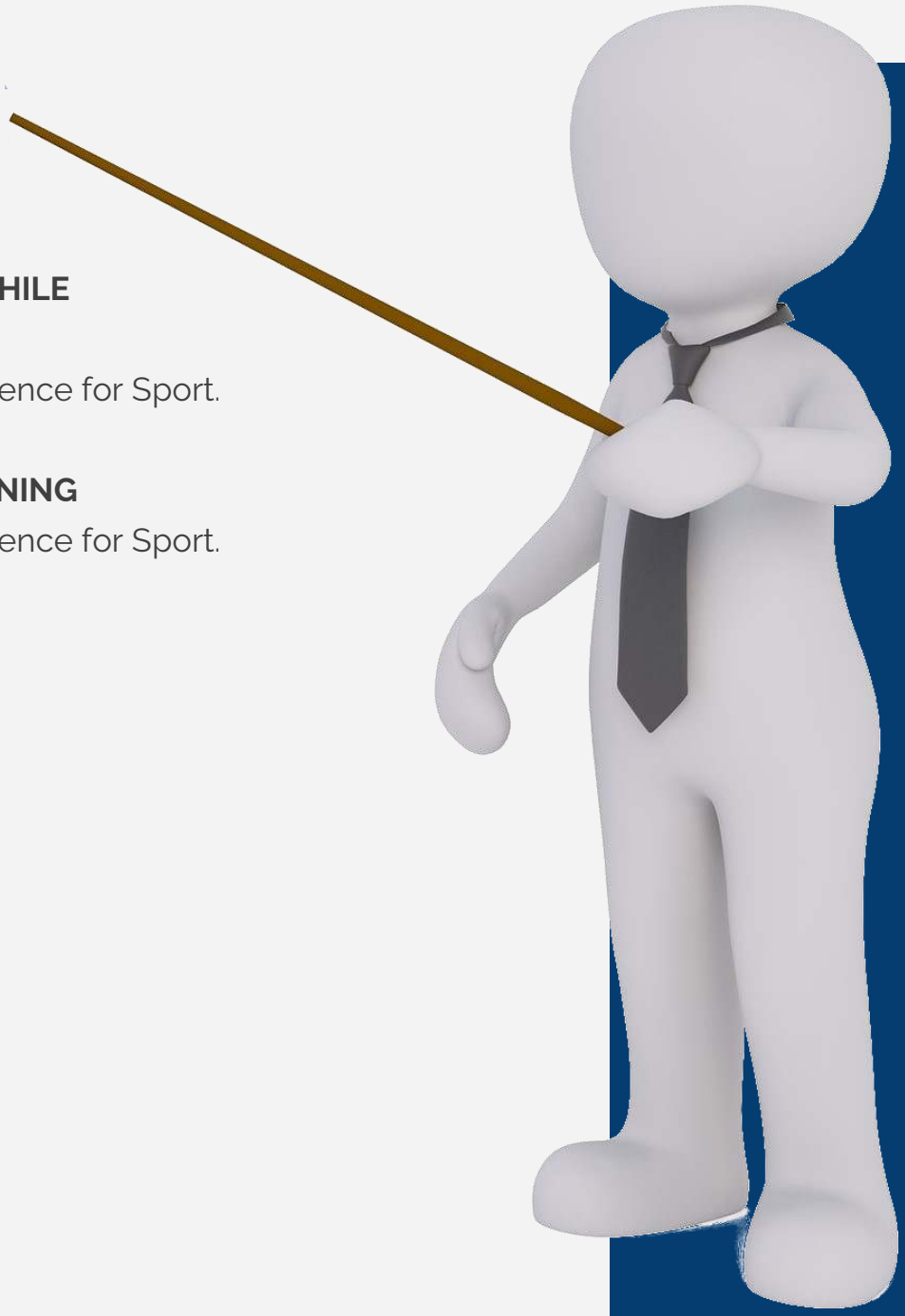
Steph's Comments

"I really appreciate that this study touches on many of the potential "myths" surrounding PFP, including the beliefs that it is really only a problem for women and that decreased hip strength is a predictive factor. Though the study pool was not large, it was a high to moderate quality meta-analysis and controlled for many factors. Therefore, we can at least take these findings into consideration.

I also feel that these conclusions can be used to properly educate athletes and patients and empower and reassure them that just because they are of the female sex, may have some muscle weakness or dynamic valgus, they are not "destined" to experience PFP."

Infographics

A round-up of our monthly research infographics.



SMALLEST WORTHWHILE CHANGE

Solomon, M. (2018) Science for Sport.

FORCE-VECTOR TRAINING

Solomon, M. (2018) Science for Sport.

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SMALLEST WORTHWHILE CHANGE

SCIENCE for SPORT

What is it?

Smallest worthwhile change (SWC) is a number that determines whether an actual meaningful change has occurred in test results.

Why is it important?

Calculating the SWC allows the coach to be confident that they can accurately determine whether a real change in performance has occurred between test and retest.

How to calculate

In team sports, it has been suggested that the SWC for elite athletes can be calculated as 0.2 multiplied by the between-subject standard deviation of the particular test.

Example

If an athlete runs a 5-10-5 shuttle test in 5.07 seconds, with the standard deviation for that particular test on that particular population being 0.15 seconds, the athlete would have to run 0.03 seconds faster to demonstrate a meaningful difference (SWC = 0.2 * 0.15).

Using SWC

Error of measurement may be greater than the SWC, if so additional statistics are useful.

Coefficient of variation

The coefficient of variation (CV) measures the degree of variation between testing trials in an individual's repeated measurements. When comparing test and retest data, using 2x CV provides more certainty, as it accounts for the chance of error in both testing periods

Meaningful change

Using the SWC, CV, and 2CV, coaches can determine the likelihood of meaningful change.

SWC = Trivial
CV = Possible
2CV = Certain

Our Summary

Due to the potential error of test results, the SWC is best used in combination with the CV and 2CV in order to identify the likelihood of a meaningful performance change between two testing sessions.

For the full article check out the Science for Sport website

SCIENCE for SPORT

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FORCE VECTOR TRAINING

SCIENCE for SPORT

What is it?

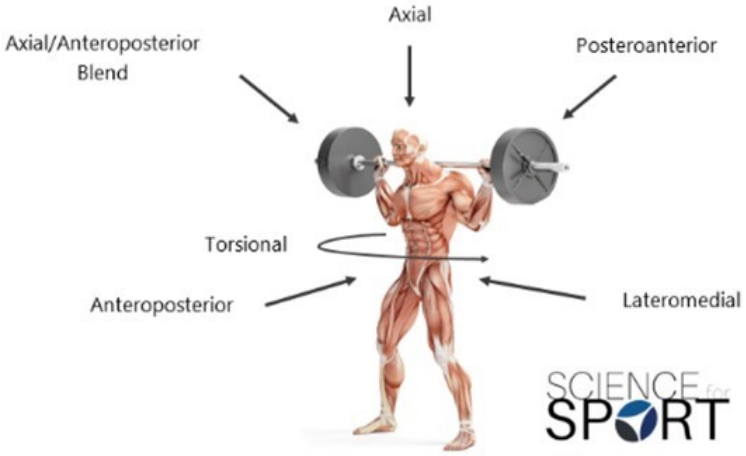
Force vector training involves characterising movement by the direction of the resistance [Figure 1].

Why use it?

In theory, by using training exercises in the same force-vector as the sport-specific movement, it is believed that there will be a greater training transfer effect.

Movement patterns

Generally, a holistic training programme may cover these 7 basic movement patterns; squat, push, pull, hinge, lunge, twist, and carry. Adding force vectors allows the coach to categorise movements that are more specific to the sport than others.



[Figure 1] Force vectors

Ratio of force

To understand the principle component of force-vector training, one must fully understand the ratio of force. The ratio of force is seen as 'force application technique', and is independent from the total force being applied. In other words, it describes how the vertical and horizontal forces are being applied to the ground during sprinting. The calculation is simple:

Ratio of force = net horizontal force (N) / net vertical force (N)

Our Summary

Force-vectors provide another layer to easily categorise exercises that may have a greater potential to transfer to competition movements. It is interesting to note that it is not the total force produced that dictates sprint performance, but rather the direction force is applied. Using force-vectors and dynamic correspondence, coaches can guide their training practices.

For the full article check out the Science for Sport website

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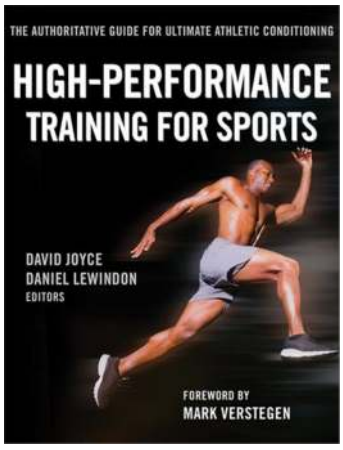

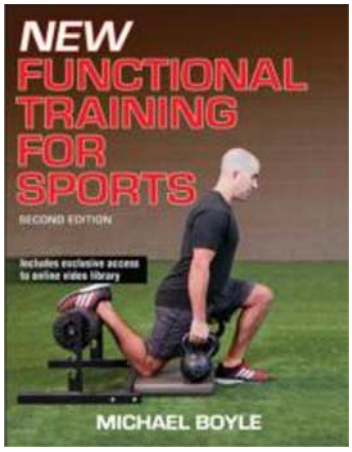

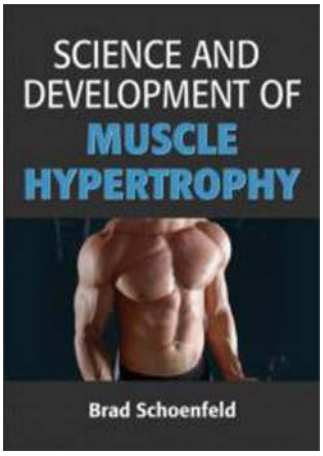

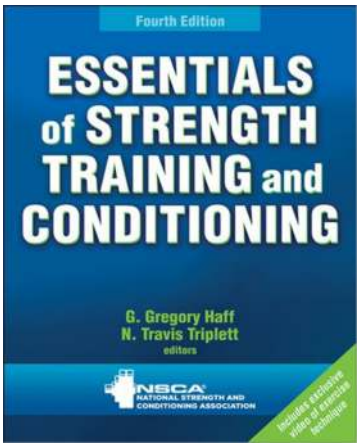

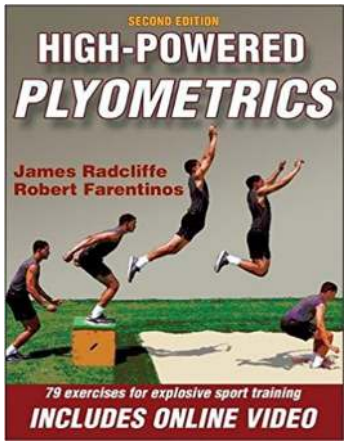

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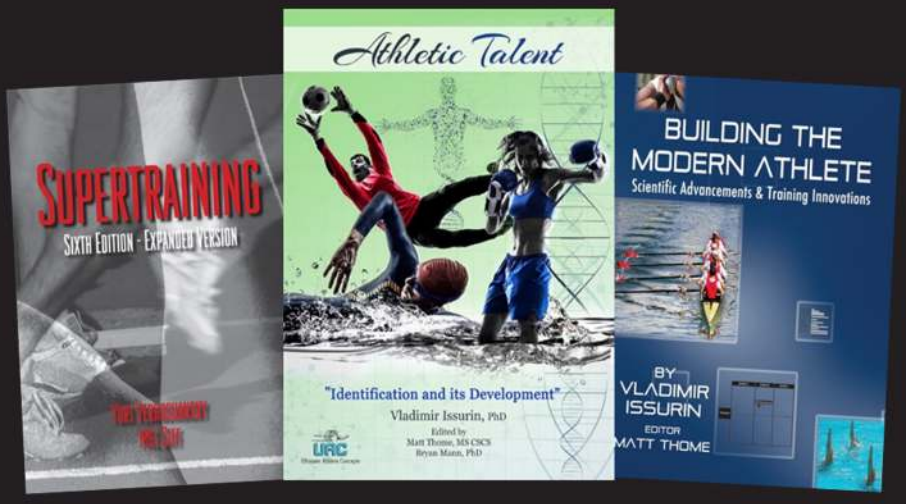

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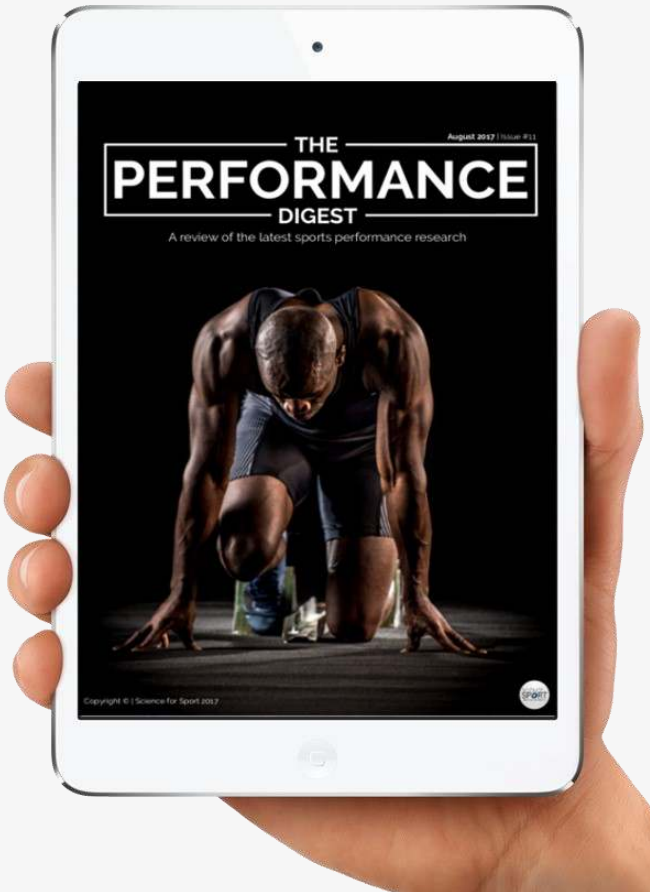

Thanks for Reading!

The next issue will be published on
1st December, 2018.

Did you like all the great content in this issue?

If so, then make sure you spread the knowledge with your friends and colleagues!

Warm Regards
Science for Sport