# Youth tennis players between the ages of **14-17** years show **slower 5m sprint times** and **increased change of direction deficit**

## Beware of the Hazard Phase: A Retrospective Analysis of Acceleration and Change of Direction Performance Across Year Groups in UK Independent School Tennis Players

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## INTRODUCTION

- Physical capacities underpinning change of direction (COD) performance are critical in competitive tennis match play.
- Biological changes within youth sport can impact expression of physical capacities related to performance.
- This study aimed to compare academic year group performance of 5m acceleration and change of direction deficit (CODD) in youth tennis players.

## METHODS

- Retrospective analysis of 3 year data set (2017-19), data collected termly.
- 142 pupil data sets collected across 5 academic year groups (9-13).
- 5m Performance + CODD (via 505 assessment) recorded.
- CODD represents the difference between average 505 and 10m time (taken from linear speed assessment).
- Data analysed via magnitude-based inferences, where consecutive year groups performances were compared.

## RESULTS

- Years 11 and 12 displayed *very likely increase* and *unclear difference* in 5m speed performance compared to year 10. (Figure 1).
- Year 11 and 12 showed a *possible increase* in CODD compared to year 10. For Year 13, CODD was *most likely lower* than years 11 and 12. (Figure 2.)

## PRACTICAL APPLICATIONS

- Results highlight the importance of early integration of acceleration and COD skill development in youth tennis players.
- Identification of possible 'hazard phase' between years 10-12, where 5m and COD performance is compromised.
- Hazard phase may coincide with normative onset of peak weight velocity (PWV), which may inhibit expression of physical capacities associated with 5m and COD performance.
- Analysis of maturational data within the hazard phase to evaluate the effects of PWV on acceleration and CODD variables may be beneficial.

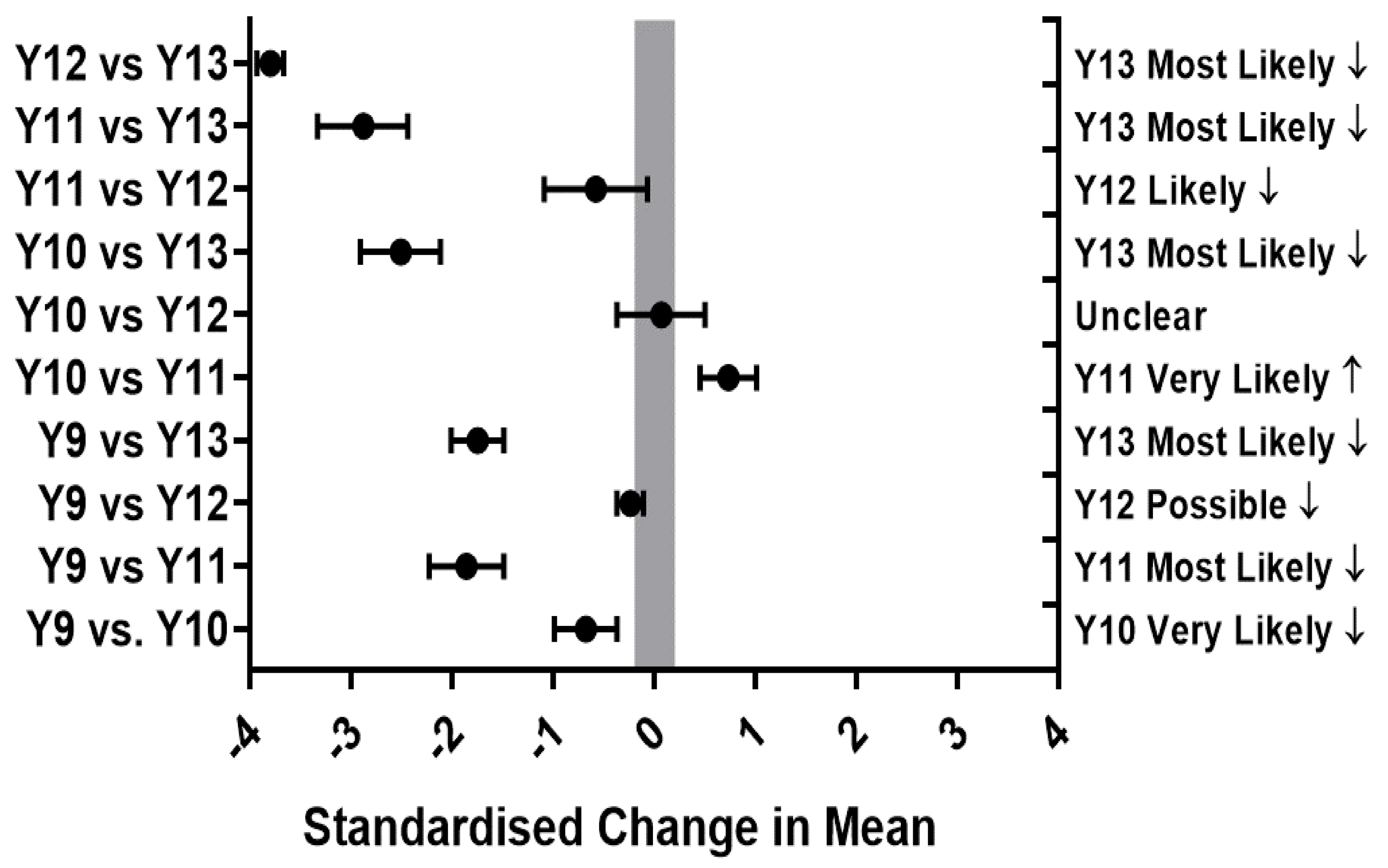


**Figure 1.** Consecutive year group differences in 5m sprint performance. Data represented as standardised change in mean (± 90% CI) with MBI's

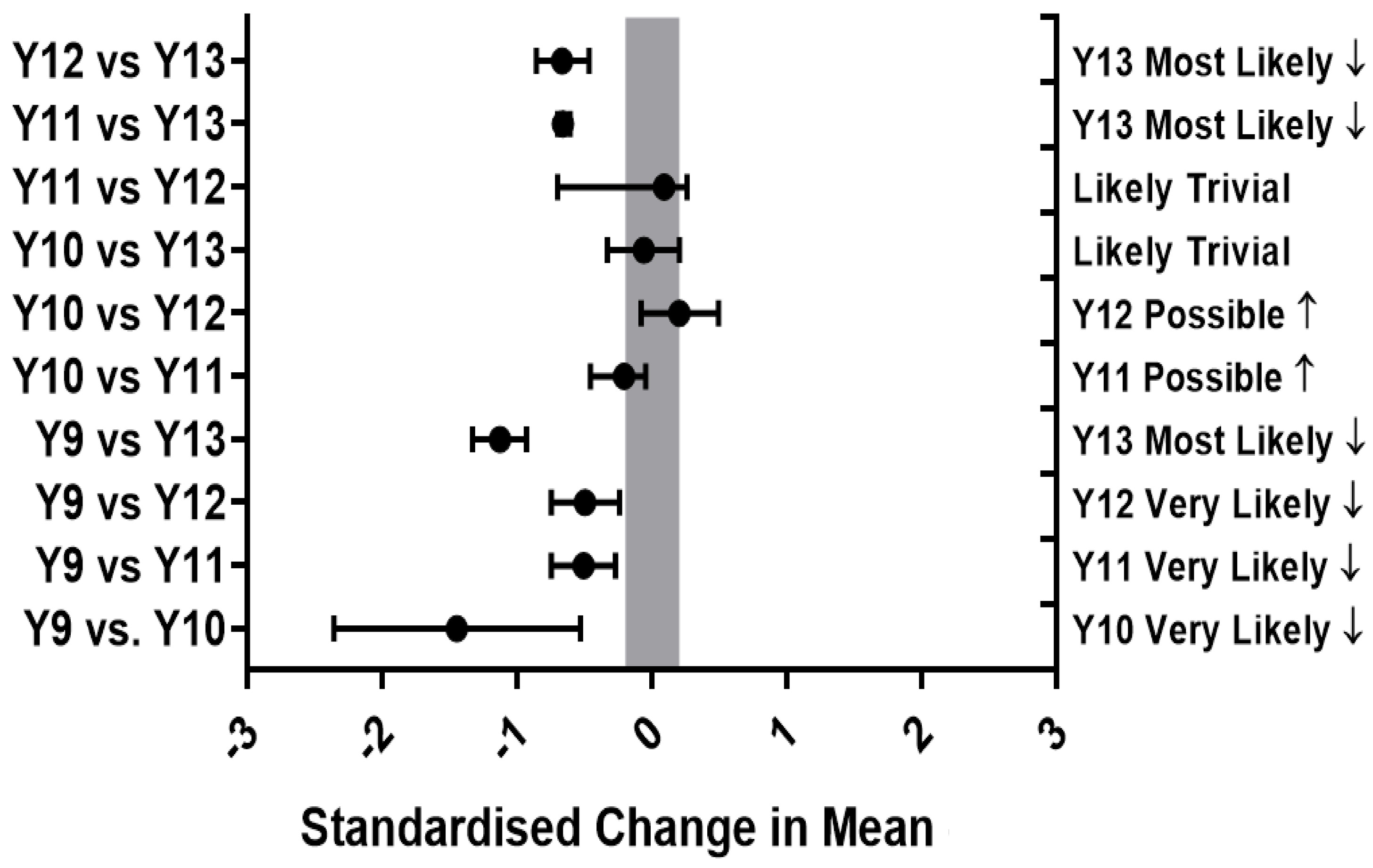


**Figure 2.** Consecutive year group differences in 505 CODD. Data represented as standardised change in mean (± 90% CI) with MBI's

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# A Study into countermovement jump eccentric phase performance and jumping height in collegiate athletes

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## Abstract

**Purpose:** The purpose of this study was to investigate the relationships between eccentric performance of countermovement jump (CMJ) and its jumping height (JH). The secondly purpose was to evaluate whether eccentric performance can be characterized among basketball, judo, weightlifting. **Methods:** Twenty four NTSU Division I athletes participated in this study(age: 20.9 ± 1 year, height: 175.37 ± 9.63 cm, weight: 76.87 ± 15.85 kg).CMJs were measured on a force platforms, force-time curves were collected for further analysis. JH, eccentric center of mass (COM) displacement, force at zero velocity (F@0V), eccentric acceleration duration (EccAccDur), minimum velocity (MinV) were calculated from a customized python software. Associations between eccentric variables and JH were used for analyzing the Person-product moment correlation. **Result:** Eccentric COM displacement, F@0V, and EccAccDur showed moderate to strong positive correlation with JH ($r$= .465~.618). F@0V and JH showed positive strong correlation ($r$ = .572), MinV and JH showed moderate negative relationships ($r$= -765) in basketball；eccentric MinV and JH showed moderate negative relationships ($r$= -.314) in Judo. In addition, eccentric COM displacement moderate relationships with JH ($r$= .320) in weightlifting. The JH, eccentric COM displacement, F@0V, EccAccDur were significant different across three sports. Weightlifters showed significantly superior JH,F@0V, EccAccDur than basketball and Judo athletes. The results indicate CMJ eccentric performance associated with JH, however, the relationships were sports dependent. Further research are needed to investigate the relationships between eccentric performance and individual sport-specific performance.

**Key words: Force-time curve, Talent identification, Vertical jumping**

## Introduction

Previous studies have focused on CMJ eccentric deceleration or concentric phase and jump performance. Various parameters including force, RFD, power output and impulse are positively correlated with JH. (Gathercole et al., 2015; Thorlund et al., 2008; Twist & Highton, 2013) However, there are few studies related to the overall eccentric phase or acceleration phase, and no comparison has been made for different sports.

## Methods

Twenty four NTSU Division I athletes participated in this study(age: 20.9± 1 year, height: 175.37± 9.63 cm, weight: 76.87 ± 15.85 kg).CMJs were measured on a force platforms, force-time curves were collected for further analysis. JH, eccentric center of mass (COM) displacement, force at zero velocity (F@0V), eccentric acceleration duration (EccAccDur), minimum velocity (MinV) (Caserotti et al, 2001) were calculated from a customized python software. Associations between eccentric variables and JH were used for analyzing the Pearson-product moment correlation.

## Result

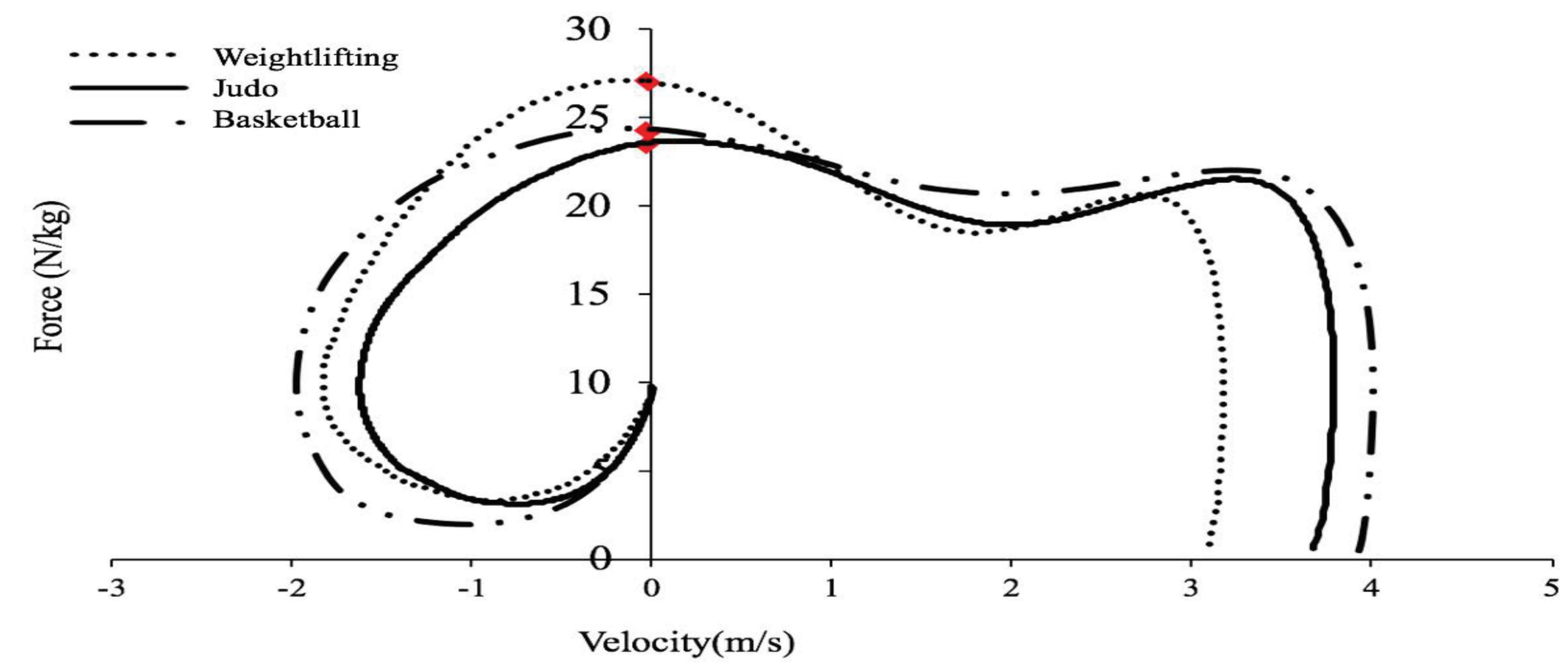
Eccentric COM displacement, F@0V, and EccAccDur showed moderate to strong positive correlation with JH ($r$= .465~.618). F@0V and JH showed positive strong correlation ($r$ = .572), MinV and JH showed moderate-negative relationships ($r$= -765) in basketball；eccentric MinV and JH showed moderate-negative relationships ($r$= -.314) in Judo. In addition, eccentric COM displacement moderate relationships with JH ($r$= .320) in weightlifting. The JH, eccentric COM displacement, F@0V, EccAccDur were significant different across three sports. Weightlifters showed significantly superior JH,F@0V( Figure1), EccAccDur than basketball and Judo athletes.(Table1)

**Table1. Differences in parameters between Basketball, Judo, Weightlifting CMJ-JH eccentric phase**

| Item | JH(cm) | COM displacement (cm) | F@0V(N) | EccAccDur(s) | MinV(m/s) |
|---|---|---|---|---|---|
| Basketball | 44.18± 4.19§ | 41.17± 5.52§ | 24.75± 1.47§ | 0.32± 0.03§ | -1.69± 0.14 |
| Judo | 41.48± 3.98§ | 42.38± 4.39 | 23.52± 3.53§ | 0.34± 0.03§ | -1.48± 0.25 |
| Weightlifting | 54.06± 9.04*+ | 47.89± 2.57* | 30.83± 2.94*+ | 0.42± 0.04*+ | -1.56± 0.20 |
| ES(ηp²) | 0.466 (M) | 0.342 (M) | 0.601 (M) | 0.634 (M) | 0.18 (S) |

JH: Jump height； COM displacement: eccentric center of mass displacement ； F@0V: force at zero velocity ； EccAccDur: eccentric acceleration duration ； minV: minimum velocity.*compared with basketball significantly； + compared with Judo significantly ；§ compared with Weightlifting significantly ；effect size: ES ( ηp²) ， Small: .01≦ $\eta^2$ ＜.058； Medium: .058≦ $\eta^2$ ＜.138； Large: .138≦$\eta^2$

**Figure1. The comparison of CMJ force-velocity curves across three sports.**




*The Basketball, Judo, Weightlifting Force-Velocity Curve ；◆：Weightlifter presented significantly higher F@0V than basketball & Judo.

## Conclusion

The results indicate CMJ eccentric performance associated with JH, however, the relationships were sports dependent. Further research are needed to investigate the relationships between eccentric performance and individual sport-specific performance.

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# Youth athletes value **psychosocial qualities** of their **strength and conditioning coaches** over technical, tactical and performance outcomes

## ‘What Does Good Coaching Look Like?’; Youth Athlete Perceptions of Effective Strength and Conditioning Coaching in a Leading UK Talent Development Environment

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| General Dimension | First Order Themes | Raw Data Themes |
|---|---|---|
| Relationship | 1st. Trust and Respect | 1st. Can trust the coach<br>2nd. Have respect for the coach<br>3rd. Be open with the coach<br>4th. Can chat about everything<br>5th. Want to work for the coach<br>6th. The coach is open about their own life |
| | 2nd. Encouragement and Support | 1st. Encouraging<br>2nd. Reassuring and reinforcing<br>2nd. Guiding<br>3rd. Positive in failure<br>4th. Good listener<br>5th. Not too disciplinary |
| | 3rd. Approachability | 1st. Approachable<br>2nd. Easy to talk to |

**Figure 1.** Athlete preferences of coach’s relationship dimension first (1st-3rd) and raw data themes. First and raw data themes presented in order of athlete preference in relation to strength and conditioning coaches.

| General Dimension | First Order Themes | Raw Data Themes |
|---|---|---|
| Coaches' Values | 1st. Motivation and Inspiration | 1st. Motivates<br>2nd. Pushes athlete beyond expectations<br>3rd. Inspires or makes athlete believe<br>4th. Challenges |
| | 2nd. Belief | 1st. Belief in athlete's potential<br>2nd. Values athlete as individual<br>3rd. Belief in athlete's ability |
| | 3rd. High Performance Expectations | 1st. Expects 100% effort<br>2nd. Focused on the goal<br>3rd. Persistent<br>4th. Expects results |

**Figure 2.** Athlete preferences of coach’s values dimension first (1st-3rd) and raw data themes. First and raw data themes presented in order of athlete preference in relation to strength and conditioning coaches.

| General Dimension | First Order Themes | Raw Data Themes |
|---|---|---|
| Coaches' Actions | 1st. Feedback | 1st. Constructive Criticism<br>2nd. Positive Feedback<br>3rd. Visual Feedback<br>4th. Continual Praise |
| | 2nd. Communication skills | 1st. Breaks things down<br>2nd. Good communicator<br>3rd. Patient when communicating<br>4th. Always in contact |
| | 3rd. Instruction | 1st. Corrects<br>2nd. Demonstrates<br>3rd. S+C knowledge<br>4th. Sports specific knowledge |

**Figure 3.** Athlete preferences of coach’s actions dimension first (1st-3rd) and raw data themes. First and raw data themes presented in order of athlete preference in relation to strength and conditioning coaches.

### INTRODUCTION

- Coach-athlete relationships (CAR) in strength and conditioning (S&C) have gained popularity in recent years.
- Elite athlete research suggests higher order psychosocial behaviours contribute to S&C CAR (Szedlack et al., 2015, 2018).
- Significant lack of S&C CAR research in youth athlete’s.
- This study aims to offer novel insight into the perceived importance of S&C CAR dimensions in youth talent development.

### METHODS

- 33 student athletes, (14-18) across 7 sports participated. Minimum 2 years S&C coaching exposure (range 2-5 years).
- Online questionnaire for each pre-identified coaching dimension (relationship, coach’s actions and values).
- Participants ranked each of the dimensions first order and raw themes in order of preference.

### RESULTS

- Highest ranked relationship themes were; (1) trust and respect, (2) encouragement and support (Figure 1).
- Highest ranked values themes were; (1) motivation and inspiration, (2) belief (Figure 2).
- Highest ranked coach actions themes were; (1) feedback, (2) communication skills (Figure 3).

### PRACTICAL APPLICATIONS

- Youth athletes value psychosocial qualities involving personal engagement and connection.
- The S&C coach role extends beyond technical and performance outcomes.
- Multi-faceted approach recommended that exceeds S&C coach perceptions to optimise CAR and athletic potential.

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# Intra- and Inter-day Reliability of Weightlifting Variables During Heavy Cleans

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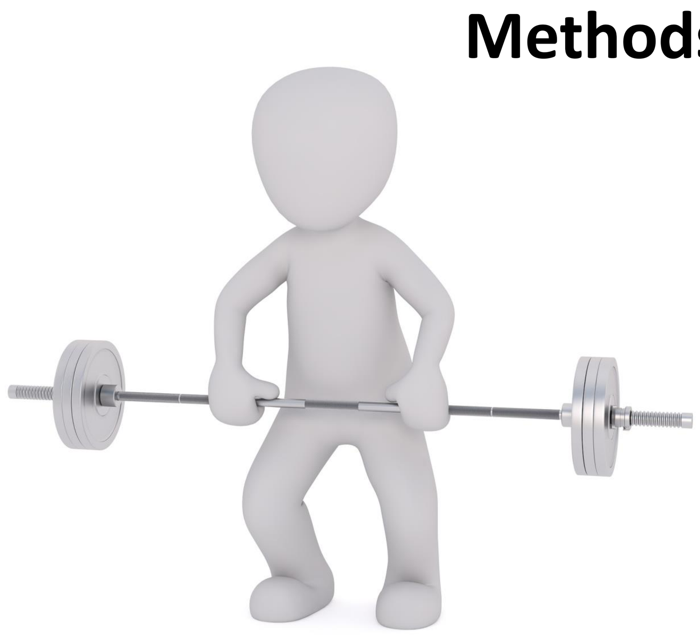
## Introduction

- The pull in weightlifting has previously been categorized into 3 phases: weighting 1 (W1), unweighting (UW), and weighting 2 (W2) (Enoka 1979).
- Research into the examination of weightlifting has typically utilized pulling derivatives initiated at or above the knee (Suchomel et al 2015; Haff et al 2012), which excludes a detailed examination of W1 and UW phases.
- Weightlifting is a sport initiated from floor level, which would imply that performance of W1 and UW may impact overall performance outcomes and therefore this study aimed to examine which variables can be collected throughout the entire duration of the pull, which of those are reliable within and between days, and which can be monitored for performance.

## Methods



**Population:**

Regional to nationally competitive weightlifters with at least one year of prior strength training (males, *n* = 4; females, *n* = 4)

**Experimental Design:** Lifters completed 3 sets of 1-repetition cleans at 90% of clean & jerk 1RM on dual force plates with 3D motion capture → Tested on 3 different days under the same conditions with at least 24 hours rest between sessions

**Data Analysis:** A customized Microsoft Excel spreadsheet was used to extrapolate and calculate variables from raw force data → Phases were determined when system weight met vGRF along the duration of the pull (Comfort et al 2012)

**Statistical Analysis:** CV and ICC with 95% CI were calculated for all variables → Pearson's Correlation Coefficient was used to identify relationships between the clean and all variables

**Number of variables analyzed per category**

Temporal Force: 27
Barbell Displacements: 10
Bar Power: 6
Bar Work: 5
System Metrics: 22
Total = 70

## Results

**Variable Sorting & Criteria**

- "Good" ICC = 0.750-0.900, "Great" ICC = > 0.900 (Koo, Li 2016)
- CV ≤ 10%
- 37 of 70 variables found to have good to great ICC & CV
- 13 of those 37 variables found to have great ICC & CV and significant correlations with 90% cleans

**Table 1** – Intra- and inter-day reliability of weightlifting variables and correlation with 90% cleans.

| Variable | Intra-day | | Inter-day (best) | | |
|---|---|---|---|---|---|
| | ICC (95% CI) | CV (%) | ICC (95% CI) | CV (%) | Pearson's R (clean kg) |
| W1 Vertical Impulse | 0.932 (0.779 – 0.987) | 5.53 | 0.964 (0.888 – 0.992) | 5.06 | 0.903 |
| W1 Average vGRF | 0.952 (0.837 – 0.991) | 6.42 | 0.961 (0.880 – 0.991) | 7.06 | 0.882 |
| W1 Average Resultant Force | 0.998 (0.994 – 1.000) | 0.64 | 0.995 (0.983 – 0.999) | 1.14 | 0.978 |
| UW Average Resultant Force | 0.984 (0.946 – 0.997) | 2.56 | 0.990 (0.957 – 0.998) | 1.92 | 0.911 |
| W2 Average Resultant Force | 0.980 (0.929 – 0.996) | 1.95 | 0.977 (0.929 – 0.995) | 2.13 | 0.910 |
| Peak Power | 0.990 (0.962 – 0.998) | 2.86 | 0.990 (0.969 – 0.998) | 3.00 | 0.933 |
| Average Power – Lift Off to W1 End | 0.990 (0.965 – 0.998) | 4.60 | 0.980 (0.937 – 0.996) | 6.84 | 0.961 |
| Average Power – W1 & UW | 0.994 (0.980 – 0.999) | 3.38 | 0.981 (0.939 – 0.996) | 6.40 | 0.948 |
| Average Power – Lift Off to Most Rear | 0.993 (0.974 – 0.999) | 3.22 | 0.976 (0.924 – 0.995) | 6.75 | 0.922 |
| Average Power – Lift Off to PBH | 0.989 (0.962 – 0.998) | 2.99 | 0.981 (0.938 – 0.996) | 5.02 | 0.985 |
| Average Power – UW to PBH | 0.973 (0.907 – 0.995) | 3.48 | 0.960 (0.874 – 0.991) | 4.53 | 0.983 |
| W1 Peak Power | 0.902 (0.686 – 0.981) | 6.89 | 0.964 (0.888 – 0.992) | 5.62 | 0.896 |
| W1 Average Power | 0.908 (0.712 – 0.982) | 6.75 | 0.940 (0.822 – 0.986) | 6.63 | 0.941 |

ICC = Intraclass coefficient correlation, CI = Confidence interval, CV= Coefficient of variation, W1 = Weighting 1, vGRF = Vertical ground reaction force, UW = Unweighting, W2 = Weighting 2, PBH = Peak bar height.

## Conclusion & Practical Applications

- After removing variables based on multicollinearity, significant correlations were shown in W1 Average Power (*r* = 0.941), W1 Average Resultant Force (*r* = 0.978), and Average Power – Lift Off to PBH (*r* = 0.985).
- Overall this demonstrates the importance of force and power outputs during W1 and should be considered when determining the overall impact in weightlifting performance especially as any change in W1 metrics could have an effect on subsequent phases of the pull.

- It can be suggested from a practical application standpoint that coaches can most easily track Average Power – Lift Off to PBH as a measure of performance through the use of readily available barbell tracking apps.
- While this study examined variable reliability, further research is needed to determine their sensitivity to change through interventions aimed at improving force and power.

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# Change of Direction Task Completion Strategy: Assessing Asymmetries

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## Introduction

It has recently been proposed that completion strategy (entry and exit time) of change of direction (COD) tasks could be examined for a greater understanding of performance[1]. When comparing COD performance in different turning directions, asymmetries have been reported in a range of populations[2]. However, these asymmetries have not been investigated in relation to the associated task completion strategy.

**Aim:** To investigate the magnitude of asymmetries in COD strategy during the 5-0-5 test and the relationships between 5-0-5 performance asymmetry and completion strategy asymmetry.

## Method & Design

Thirty-six youth athletes (height: 170.9 ± 9.6 cm; mass: 66.1 ± 12.9 kg; maturity offset: 2.4 ± 0.7 years post PHV) performed three 5-0-5 trials in each turning direction (clockwise and anti-clockwise). Asymmetries (Dominant [D] vs Non-dominant [ND]) were calculated using the percentage difference method[3]. Participants with a percentage asymmetry greater than their individual maximum CV%[4] were considered asymmetrical (n = 11). Only the asymmetrical group was used for further analysis. Task completion strategy was measured by; initial approach time (0-10m), full approach time (0-15m) entry time (10-15m) and exit time (15-20m). Performance and strategy variables were compared between directions using a Paired Samples T-test and a Pearson's Correlation established relationships between COD strategy asymmetries and 5-0-5 asymmetries.

**Entry time (s) =**
*Time from 10m gate to the 15m turn line (+50% ground contact time)*

**Full approach time (s) =**
*Time from 0 to 10m (**Initial approach time**) plus entry time.*

**Exit time (s) =**
*Time from turn line (+50% ground contact time) to the 10m gate*

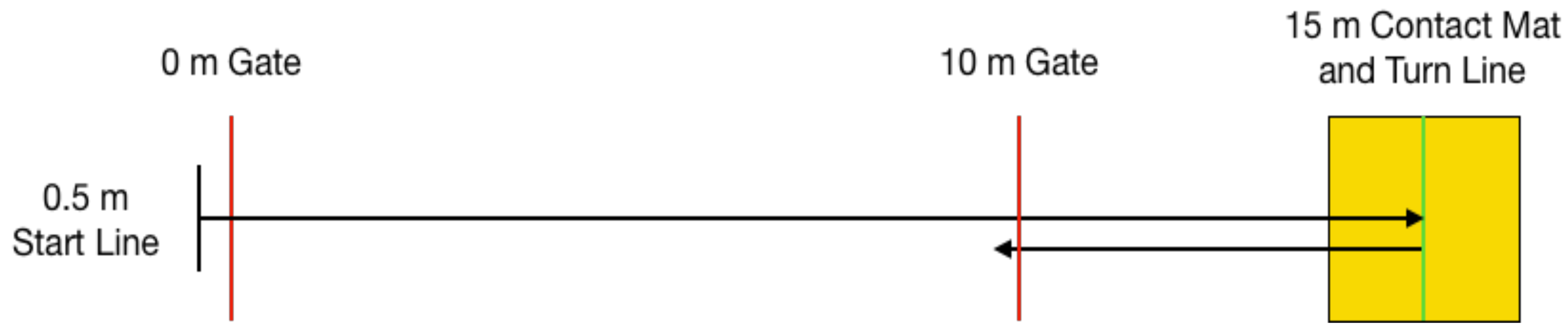


**Figure 1.** Schematic presentation of the 5-0-5 test

## Results

There were significant differences between turning directions for 5-0-5 time, entry time and full approach time (Table 1).

**Table 1:** Descriptive statistics and reliability data for COD metrics

| Metric | Direction | Mean ± SD | Mean asymmetry % | CV% |
|---|---|---|---|---|
| 5-0-5 (s) | ND<br>D | 2.61 ± 0.13<br>**2.49 ± 0.14*** | 4.88 ± 1.24 | 5.14<br>5.88 |
| Initial approach (s) | ND<br>D | 1.92 ± 0.08<br>1.94 ± 0.14 | 0.64 ± 5.39 | 4.63<br>7.23 |
| Full approach (s) | ND<br>D | 3.15 ± 0.14<br>**3.02 ± 0.20*** | -4.43 ± 5.50 | 4.55<br>6.59 |
| Entry (s) | ND<br>D | 1.23 ± 0.08<br>**1.12 ± 0.11*** | -8.22 ± 7.46 | 7.03<br>10.00 |
| Exit (s) | ND<br>D | 1.38 ± 0.08<br>1.36 ± 0.07 | -1.72 ± 5.36 | 5.14<br>5.62 |

ND = Non-dominant; D = Dominant;. *Statistically significantly ($p < 0.05$).

**Table 2:** Relationship between asymmetry scores across COD metrics

| | Initial approach | Full approach | Entry | Exit |
|---|---|---|---|---|
| 5-0-5 | -0.22 | -0.18 | **-0.65*** | 0.38 |
| Initial approach | 1 | **0.81*** | 0.34 | -0.34 |
| Full approach | | 1 | **0.61*** | **-0.68*** |
| Entry | | | 1 | **-0.95*** |
| Exit | | | | 1 |

*Statistically significantly ($p < 0.05$).

Entry time asymmetry percentage was the only COD strategy variable to have a significant *negative* correlation to 5-0-5 asymmetry percentage (Table 2).

However, exit time asymmetry and full approach time asymmetry displayed a significant *negative* association with entry time asymmetry (Table 2).

## Conclusions

The results indicate that individuals with an asymmetry in overall 5-0-5 performance who enter their ND turn faster, demonstrate a slower exit speed and subsequently a *greater* asymmetry in 5-0-5 performance. This may be attributed to a lack of centre of mass control during deceleration or poor joint co-ordination during the entry phase, negatively impacting exit time via poor application of propulsive impulse. Therefore this may point towards asymmetrical athletes entering the turn on their ND side too fast, despite already showing a performance asymmetry. The identification of this performance limitation may provide useful information to coaches although further investigation to aid understanding is required.

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# Physical performance characteristics of elite female international footballers

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## INTRODUCTION

Over the last twenty years female participation in football has experienced rapid growth. Global participation grew from 22 million participants in 2000 to 30.15 million participants in 2014. Such rapid growth has resulted in a substantial increase in the number of competitive domestic and international matches being played by elite female footballers.

Therefore the need to objectively assess the physical performance capabilities of elite female footballers to optimally prepare player's to meet the demands of training and competing at national and international levels has never been greater(Manson et al 2014).

The aim of this study is to identify the physical performance characteristics of elite Irish female international footballers.

## METHODS

Elite Female international Footballers ( n=12; mean± SD; Age 22.45 ± 5.06 yrs, height 170 ± 6.4 cm , body mass 65.44 ± 8.65 kg) took part in the following anthropometric and physical performance tests ( see Fig.1).

Figure.1 performance testing running order


Participants took part in a standardised R.A.M.P warm up protocol prior to performance testing.

**Height:** measured using Marsden HM-250P , portable Leicester stadiometer, Rotherham ,England.

**Weight:** measured using a Seca, 769 , portable scales, Hamburg , Germany.

**Counter Movement Jumps:** were measured using ,ForceDecks, dual force plate system, London, England. Participants had one sub maximal trial effort before three maximum efforts were recorded.

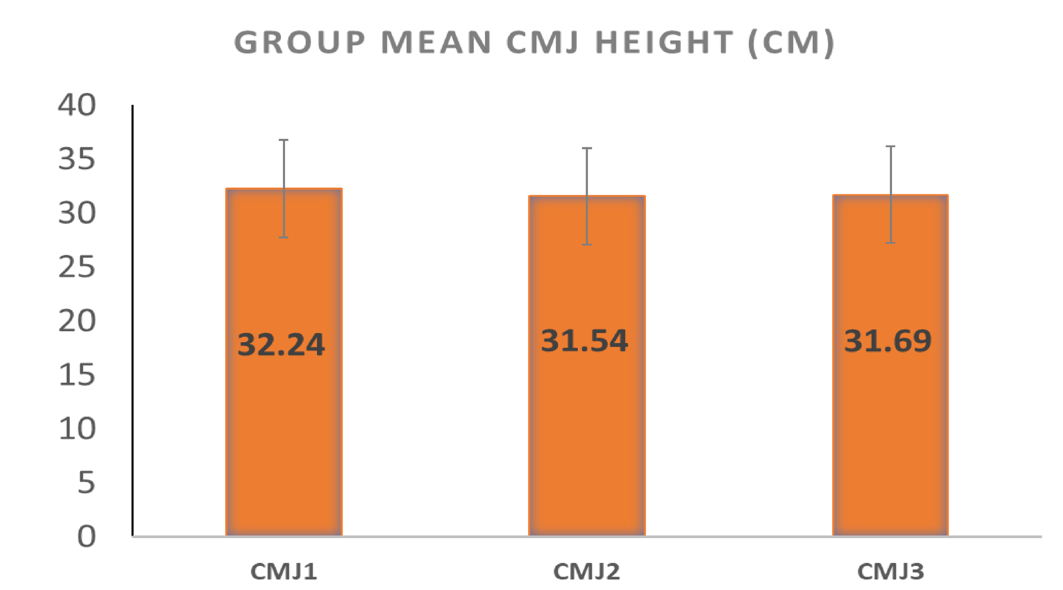
**10/5 Repeated Hop Tests**: were measured using the Micro-gate, Opto-jump ,Next system , Bolzano, Italy. Participants had one sub maximal trial effort before three maximum efforts were recorded.

**Linear Sprints :** were measured using the Micro-gate ,Witty timing system, Bolzano , Italy. Participants had three sub maximal trial efforts before three maximum efforts were recorded.

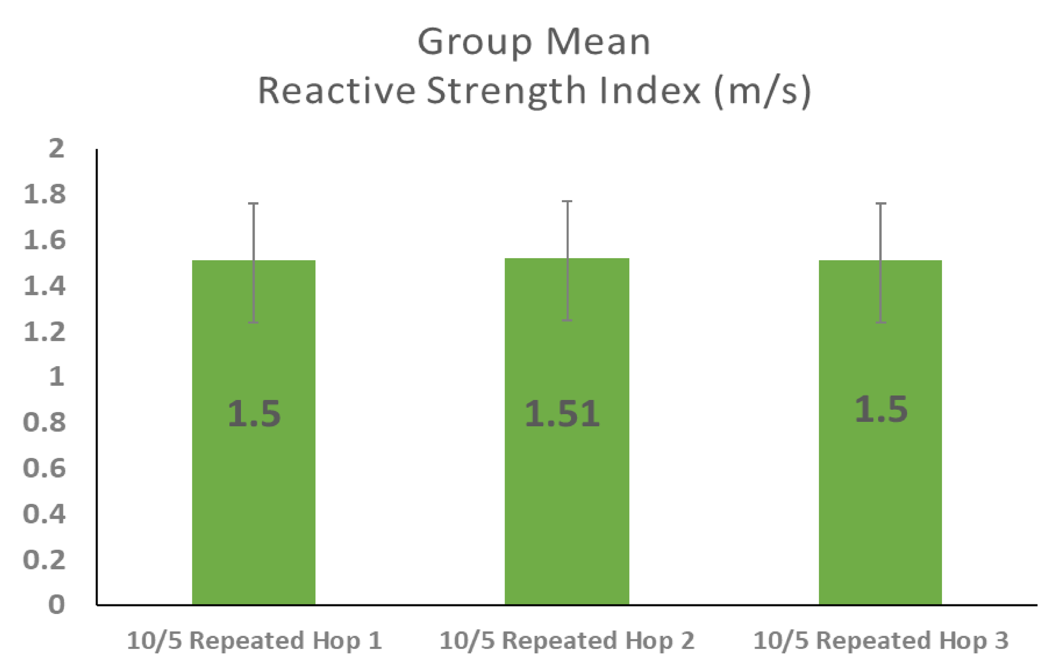
**Repeat Sprint Ability:** was measured using the Micro-gate ,Witty timing system, Bolzano , Italy. Participants had one sub maximum effort trial before one maximum effort was recorded. The test devised by (Gabbett 2010) consisted of 6 X 20-m maximal effort sprints on a 15-second cycle. On the completion of each sprint, participants performed a 10-m deceleration and a 10-m active jog recovery

**Yo – Yo IR Level 1:** Standardised protocol as per (Bangsbo 1994, 2003)

## RESULTS




Graph.1: Group mean counter movement jump height. Standard deviations; CMJ1: ± 3.64cm , CMJ2: ± 4.43cm , CMJ3: ± 4.50cm.




Graph.2: Group mean 10/5 repeated Hop RSI score. Standard deviations; 10/5 RH1: ± .24m/s , 10/5 RH2 ± .26 m/s, 10/5 RH3 : ± .26 m/s.

| Trial. No | Subjects | 0 - 5m | 0 - 10m | 0 - 20m | 0 - 30m | Rolling 20m |
|---|---|---|---|---|---|---|
| Linear Sprint 1 | n=11 | 1.12 ± .07 | 1.91 ± .09 | 3.29 ± .17 | 4.58 ± .26 | 2.67 ± .18 |
| Linear Sprint 2 | n = 10 | 1.17 ± .10 | 1.97 ± .12 | 3.32 ± .19 | 4.62 ± .27 | 2.66 ± .17 |
| Linear Sprint 3 | n = 10 | 1.15 ± .08 | 1.94 ± .11 | 3.29 ± .18 | 4.60 ± .27 | 2.67 + .17 |

Table.1 Linear Sprint Group Mean - Split Times (sec)


Graph.3 Repeat Sprint Ability Group means:
Run 1: 3.37+ .17 , Run 2: 3.41 + .16 , Run 3: 3.50 + .19
Run 4: 3.54 ± .19 , Run 5: 3.58 ± .22 , Run 6: 3.59 ± .23

**Yo – Yo IR Level 1:**
Group Mean Distance ± St Deviation : 1416 ± 277m
Group Mean Level ± St Deviation : 16.9 ± .88

## DISCUSSION

This research data indicates as a group this cohort displayed similar physical performance characteristics as other elite female international footballing cohorts.

**Counter movement jump height:** Norway; 30.7 ± 4.1 cm (Haugen et al 2012), Italy ; 31.6 ± 4.0cm ( Datson et al 2014).

**Linear Sprints:** data illustrated this cohort were slower over 0 – 10m and 0-20m in comparison to their Norwegian counterparts ,1.67 ± .07 sec, 3.1sec (Haugen et al 2012) vs 1.89 ± .09 sec , 3.26 sec. Though this group did display marginally quicker 0 – 5m and 0 – 10m times than an Australian cohort , 1.14 ± .04 sec , 1.91 ± .04 sec vs 1.09 ± .07 sec, 1.89 ± .09 sec.

**Repeat sprint ability:** Australia 20.9 ± .5 ,total time (sec) vs 20.97 ± 1.1 ,total time (sec) in this study.

**Yo – Yo IR Level 1:** data supported the premise that higher level players cover greater distances in the Yo-Yo IR level 1. As Danish and Spanish top division cohorts reported mean values of 1379 m and 1224 ± 225 vs 1416 ± 277m in this study.

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## ACKNOWLEDGEMENTS

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# A COMPARISON BETWEEN THE DROP JUMP AND 10/5 REPEATED JUMPS TEST TO MEASURE THE REACTIVE STRENGTH INDEX

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## Introduction

The drop jump (DJ) is a common test for evaluating reactive strength index (RSI) (Markovic, 2007; Marshall & Moran, 2013). However, limitations of the DJ test include 1) a box is required and 2) individuals will likely either lower or heighten their centre of mass (dependent on strategy) before 'dropping' from the box. Consequently, between-session/athlete comparisons of DJ-derived RSI values may lack efficacy. The purpose of this study was, therefore, to compare RSI values obtained from the DJ test to those derived by an alternative test, the 10/5 repeated jumps test (RJT), which overcomes the aforementioned limitations.

## Methods

Following institutional ethics approval, 30 male sports students who competed in team-sports performed a standardised warm-up and familiarisation prior to testing. Participants then completed a total of 9 maximal-effort jumps; 3 x DJs from a 30 and 40 cm high box and 3 x 10/5 RJT in a randomised order. The participants kept their arms akimbo and were instructed to "aim for maximum height whilst minimising contact time". Jumps were performed on an in-ground force plate sampling at 1000 Hz. Raw force-time data were analysed in Microsoft Excel, where mean values for RSI, jump height (JH) and ground contact time (GCT) were identified. RSI was calculated by JH/GCT. A Shapiro-Wilk test was used to determine normality. A repeated measures ANOVA with Bonferroni corrections was used to examine differences in RSI, JH and GCT between tasks. Pearson correlation coefficients determined relationships between variables and the intraclass correlation coefficient (ICC) values informed the reliability of the jump data.

## Results

The 10/5 RJT and DJ tests demonstrated good-excellent (ICC ≥ 0.813) between trial reliability for JH and RSI and moderate-good (ICC = 0.598-0.782) between trial reliability for GCT. Differences in JH, GCT and RSI between the RJT and DJ tests are visually presented in Figure 1. Trivial and non-significant differences in RSI were noted between tests (p=0.540). Small but significant differences in JH between the RJT and both DJ tests (p≤0.004) were noted, with JH being higher for the DJs. Moreover, significant differences in GCT were observed between jump tasks (p≤0.001) with the shortest occurring for the RJT. The RSI derived from the RJT and DJ tests demonstrated a large association ($R^2$=30%), as shown in Figure 2, whereas GCT and JH showed a small to moderate association ($R^2$=0% and $R^2$=25%, respectively).

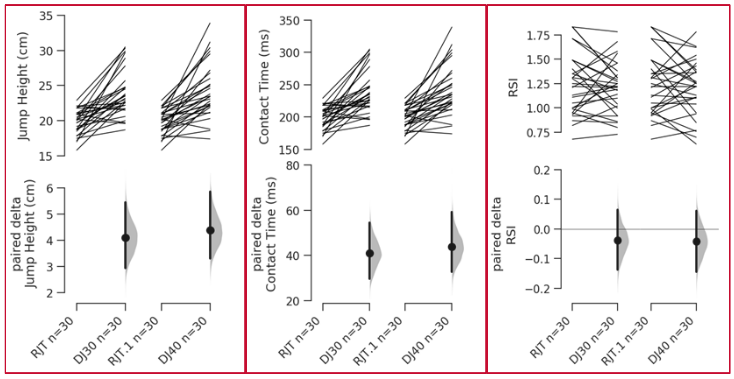


**Figure 1: Differences in jump height (left), contact time (middle) and RSI (right) between the RJT and DJ tests.**

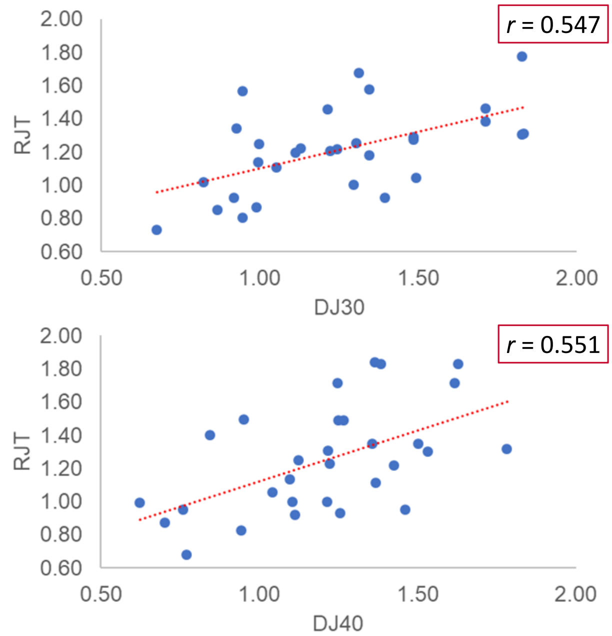


**Figure 2: Scatter plots showing the relationships between RSI calculated from the RJT and DJ tests from 30 cm (top) and 40 cm (bottom).**

## Summary and Conclusion

Practitioners with limited time and resources may benefit from using the 10/5 RJT when measuring an athlete's RSI. Analysis revealed that the RJT yields slightly greater RSI values and lower mean GCTs in comparison to both DJ tests. Furthermore, by using the 10/5 RJT, coaches would eliminate the aforementioned limitations associated with DJ testing. Although, the coefficient of determination revealed that RSI derived from the 10/5 RJT and DJ tests cannot be used interchangeably. Thus, values must not be compared due to the dissimilarities between the jump tests.

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# High-velocity muscular power training improves functional outcome measures in older adults.

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## 1. Introduction

High-velocity muscular power training interventions are being explored as a potentially low-cost way to improve quality of life and reduce health care costs for older adults (Da Rosa et al, 2018).

Interestingly, muscular power reduces at a faster rate and is more associated with functional task performance than muscular strength in older adults (Gernster et al, 2017).

This is underpinned by reductions in neural drive, motor unit synchronisation, rate of force development and the subsequent atrophy of fast twitch muscle fibres (Caserotti et al, 2008).

The decrease in physical function caused by these factors is the initial stage of the age-related muscular disease sarcopenia (Cruz-Jentoft, 2018).

Sarcopenia is one of the most debilitating physiological effects of ageing and costs an estimated £2.5 billion annually in the UK (Villanueva et al, 2018).

Due to this, the older age demographic are particularly in need of effective resistance training interventions to maintain overall health and physical function in later life (Public Health England, 2018).

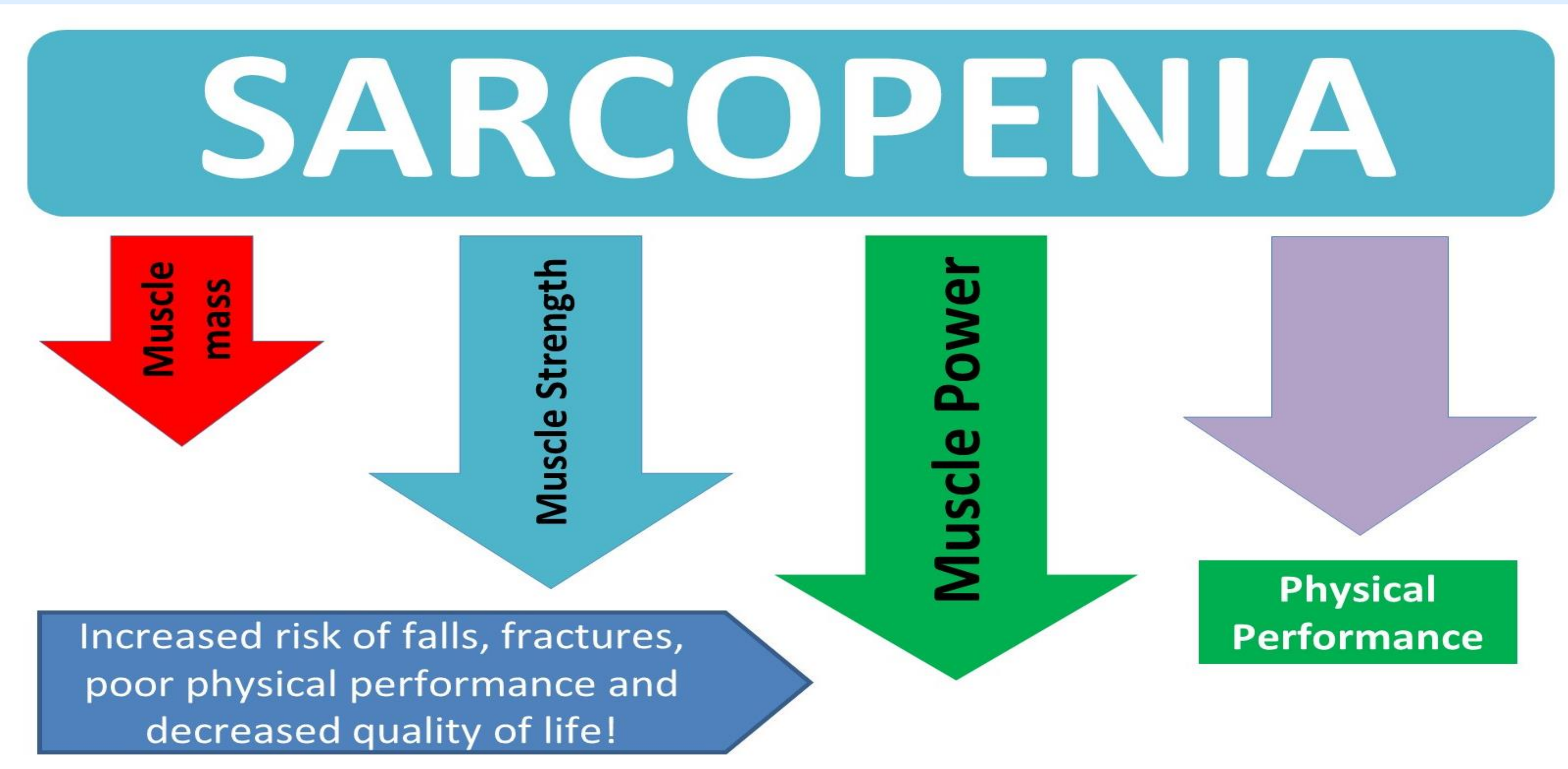


*Figure 1. Underpinning characteristics of sarcopenia and effects on physical performance. (Movement for Movement, 2018).*

## 2. Aim

The purpose of this systematic review was to evaluate the effectiveness of high-velocity muscular power training programmes on functional outcome measure performance in older adults aged 65 years and over.

## 3. Method

***Search Strategy:***

CINAHL, MEDLINE, and SPORTDiscus were searched along with grey literature to identify appropriate articles.

***Inclusion and exclusion criteria:***

Inclusion and exclusion criteria were set to ensure that the search only targeted studies that were relevant to the research question.

***Critical Appraisal:***

Methodological quality was assessed using the McMaster quantitative appraisal tool and results presented using the PRISMA framework.

| | |
|---|---|
| ***Population:*** | Participants in all studies were aged 65 years or over, were free from any major health condition and involved a mixture of men and women. |
| ***Intervention:*** | The intervention used was required to include a replicable high-velocity training programme with a minimum duration of 6 weeks. |
| ***Comparison:*** | To determine the effectiveness of the high-velocity muscular power training programmes they had to be compared to a control group with no intervention or a traditional resistance training (RT) intervention. |
| ***Outcomes:*** | The primary outcomes that were analysed during the systematic review included functional outcome measures that are related to muscular power. |

*Table 1. PICO Characteristics.*

## 4. Results

### *Search Results*

The electronic database search yielded 231 records and this was reduced to eight trials with 328 participants for inclusion in this systematic review (Earles et al, 2001; Miszko et al, 2003; Henwood et al, 2005; Henwood et al, 2008; Marsh et al, 2009; Lesczcak et al, 2013; Glenn et al, 2015; Sayers et al, 2016).

### *Cohort Characteristics*

Untrained older adults were used in the majority of studies. Some studies targeted participants who were identified as having lower or higher levels of physical function.

### *Intervention Characteristics*

The programming variables used were highly varied between studies. The intent to complete repetitions with maximal intended velocity and primary focus on lower limb musculature was the underlying similarity.

### *Impact on Functional Outcome Measures*

A range of outcome measures associated with muscular power were used including walking speed tests, stair ascent tests, timed sit to stands and balance assessments. Small to large effect sizes were apparent in all studies in favour of high-velocity training when compared to untrained controls or RT.

### *Safety Concerns*

Three out of the eight studies highlighted potential safety concerns due to injuries occurring to participants during their studies. No pre-conditioning period and inappropriate exercise selection were the main risks.

### *Limitations*

The search strategy was conducted by one person and this can increase the risk of bias towards study selection. Due to methodological characteristics and statistical approaches used in some of the review studies there was a moderate risk of bias.

## 5. Practical Application

- High-velocity muscular power training exercises can be used to improve physical performance in suitable older adults.
- The key determinant underpinning improved outcome measure performance was using a maximum intended movement velocity at sub maximal loads, with a primary focus on lower limb exercises.
- Improvements are possible with a relatively low training volume and across a range of loads (0-75% 1RM).
- A pre-conditioning period of 2-4 weeks is recommended before using high-velocity exercises with untrained older adults.
- As the training frequency and length of interventions were associated with improved outcomes, promoting long term adherence is vital.

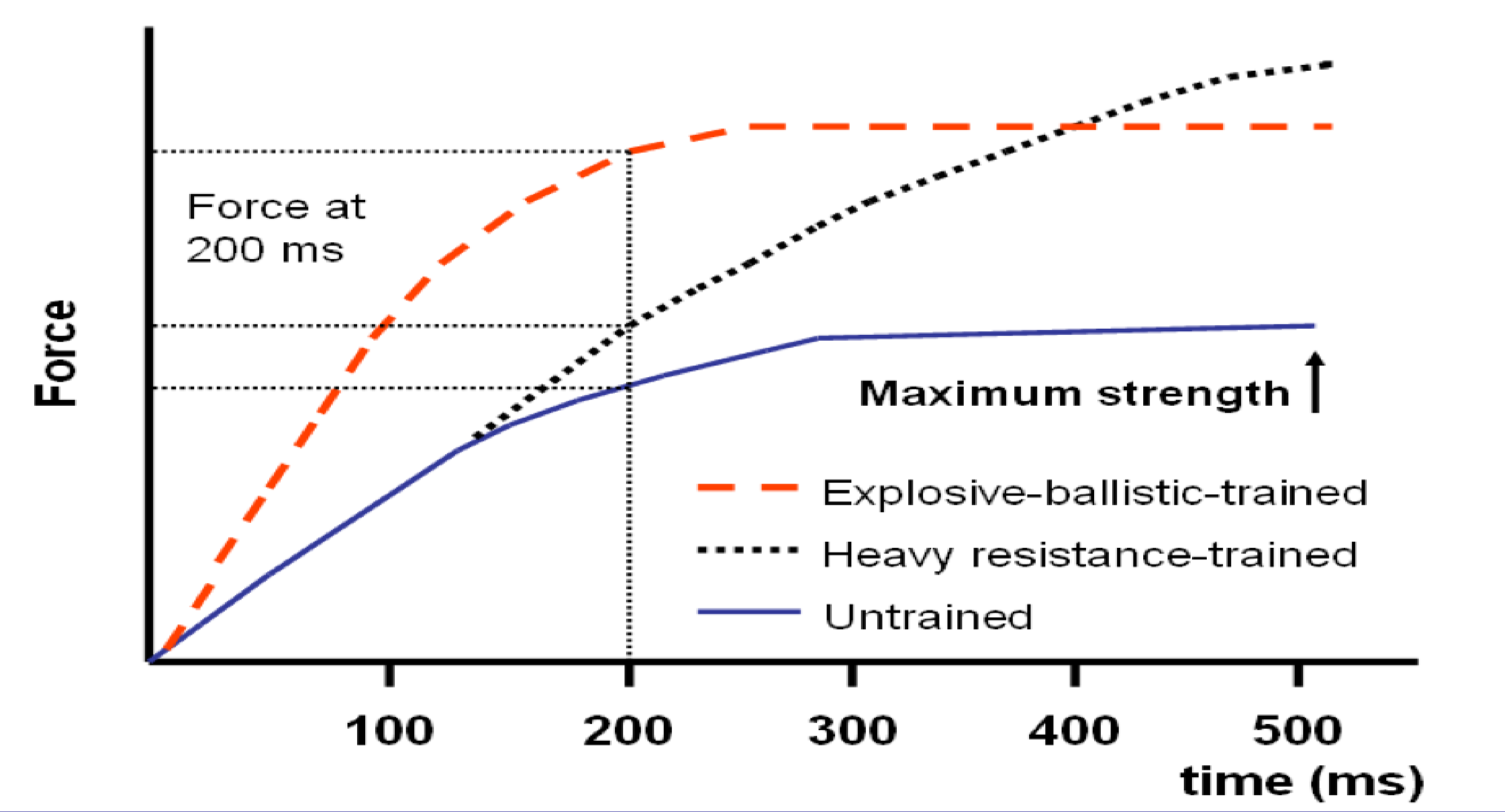


*Figure 2. Force time curve (Aagaard et al, 2002).*

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# High intensity accelerations and decelerations: What are the demands of elite team sports competitive match-play?

**Damian Harper[1,2], Chris Carling[2] & John Kiely[2]**

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## INTRODUCTION

- At the highest standard of competitive match play there has been an evolutionary progression in the high intensity work load profile of the contemporary team sports player [1–4].
- Intense accelerations and decelerations make up a substantial part of the high-intensity workload and therefore have particular important implications for performance enhancement and injury risk reduction.
- High intensity accelerations and decelerations place distinctive and disparate internal (physiological) and external (biomechanical) loading demands on players [5].
- Therefore, careful monitoring of each of these specific actions during training and match-play is of significant importance to effective player load management systems, and is common practice amongst practitioners working with players at the elite level [9].
- GPS devices are most commonly used to quantify the occurrence and characteristics of higher intensity accelerations and decelerations during competitive match-play.
- There is currently no systematic review or meta-analysis that has specifically focused on quantifying and comparing the occurrence of higher intensity accelerations and decelerations during competitive match-play across a range of team sports in elite players.

## AIMS

1. Compare differences in the frequencies of high ($\geq$ 2.5m.s$^{-2}$) intensity accelerations and decelerations in elite team sports competitive match-play.
2. Review the methodological procedures used to quantify the occurrence of high intensity accelerations and decelerations during elite competitive match-play when measured using GPS devices.

## METHODS

- A systematic review of four electronic databases (CINAHL, MEDLINE, SPORTDiscuss, Web of Science) was conducted to identify peer reviewed manuscripts that had reported high intensity ($\geq$ 2.5m.s$^{-2}$) accelerations and decelerations concurrently in elite team sports competitive match-play.
- A Boolean search phrase was developed using key words synonymous to team sports (population), acceleration and deceleration (comparators) and match-play (outcome).
- Articles only eligible for meta-analysis were those that reported high ($\geq$ 2.5m.s$^{-2}$) intensity accelerations and decelerations concurrently using GPS devices (sampling rate: $\geq$ 5Hz) during elite able-bodied (mean age: $\geq$ 18 years) team sports competitive match-play (match time: $\geq$ 75%).
- 'Level of eliteness' was classified independently by two authors (DH, CC) using a modified version of Swann et al. [6] which allows within and between sport comparisons to be made.
- Using recent guidelines recommended for the collection, processing and reporting of GPS data [7] a checklist was produced to help inform a judgement about the methodological limitations aligned to 'data collection', 'data processing' and 'normative profile' for each eligible study. For every study, each outcome was rated as either 'low', 'unclear' or 'high' risk of bias (RoB).
- Meta-analysis was performed using Review Manager software (RevMan 5.2) to compare standardised mean differences (SMD) in the frequency of high intensity accelerations versus decelerations during match-play.
- SMD was interpreted with a qualitative scale using the thresholds outlined by Hopkins et al. [8]: < 0.2 = trivial; 0.2 - 0.6 = small; 0.6 – 1.2 = moderate; 1.2 – 2.0 = large; 2.0 – 4.0 = very large; > 4.0 = extremely large

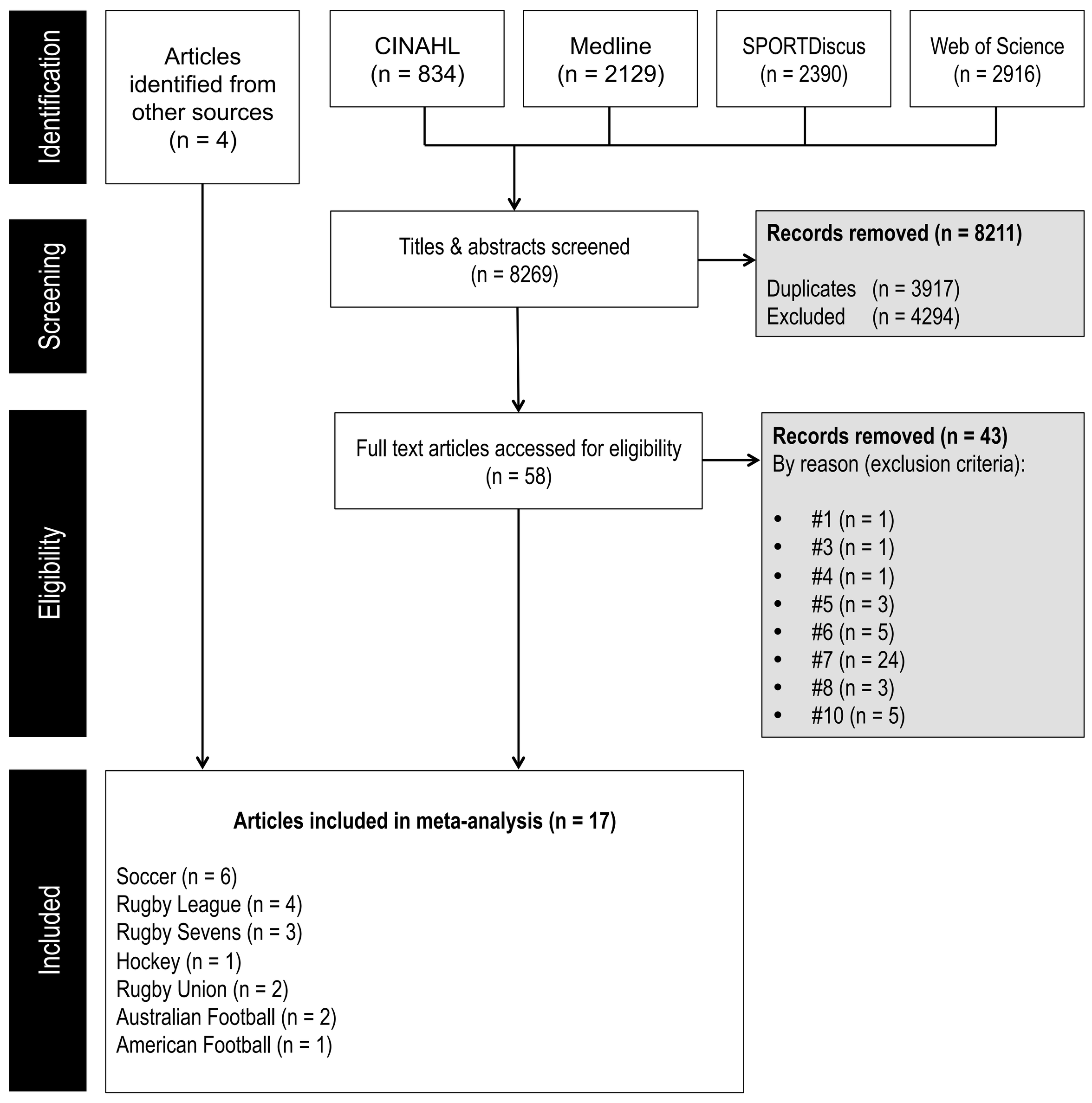


**Fig. 1** Step by step process leading to identification of eligible studies. *#1 non-peer reviewed manuscript*, #3 not able-bodied elite athlete, *#4 players with mean age* $\leq$ *18 years, #5 not competitive match-play, #6 GPS devise with sampling frequency < 5Hz, #7 reported accelerations or decelerations in isolation or as a combined metric (i.e. explosive distance), #8 did not report full match, #10 studies using same data set.*

## RESULTS

- A total of seventeen studies met the eligibility criteria, comprising seven team sports with a total of 469 male participants aged between 18 to 29 years (see PRISMA flow chart, Fig. 1).
- Samples of players across all sports were classified as world-class elite (*n* = 11, 55%), successful elite (*n* = 8, 40%) and competitive elite (*n* = 1, 5%). One study reported data from two different samples of elitism [19].
- Analysis showed only American football reported a greater frequency of high (SMD = 1.26; 95% confidence interval (CI): 1.06 to 1.43) intensity accelerations compared to decelerations (see Fig. 2).
- All other sports had a greater frequency of high intensity decelerations compared to accelerations, with soccer demonstrating the greatest difference (SMD = -1.74; 95% CI -1.28 to -2.21).

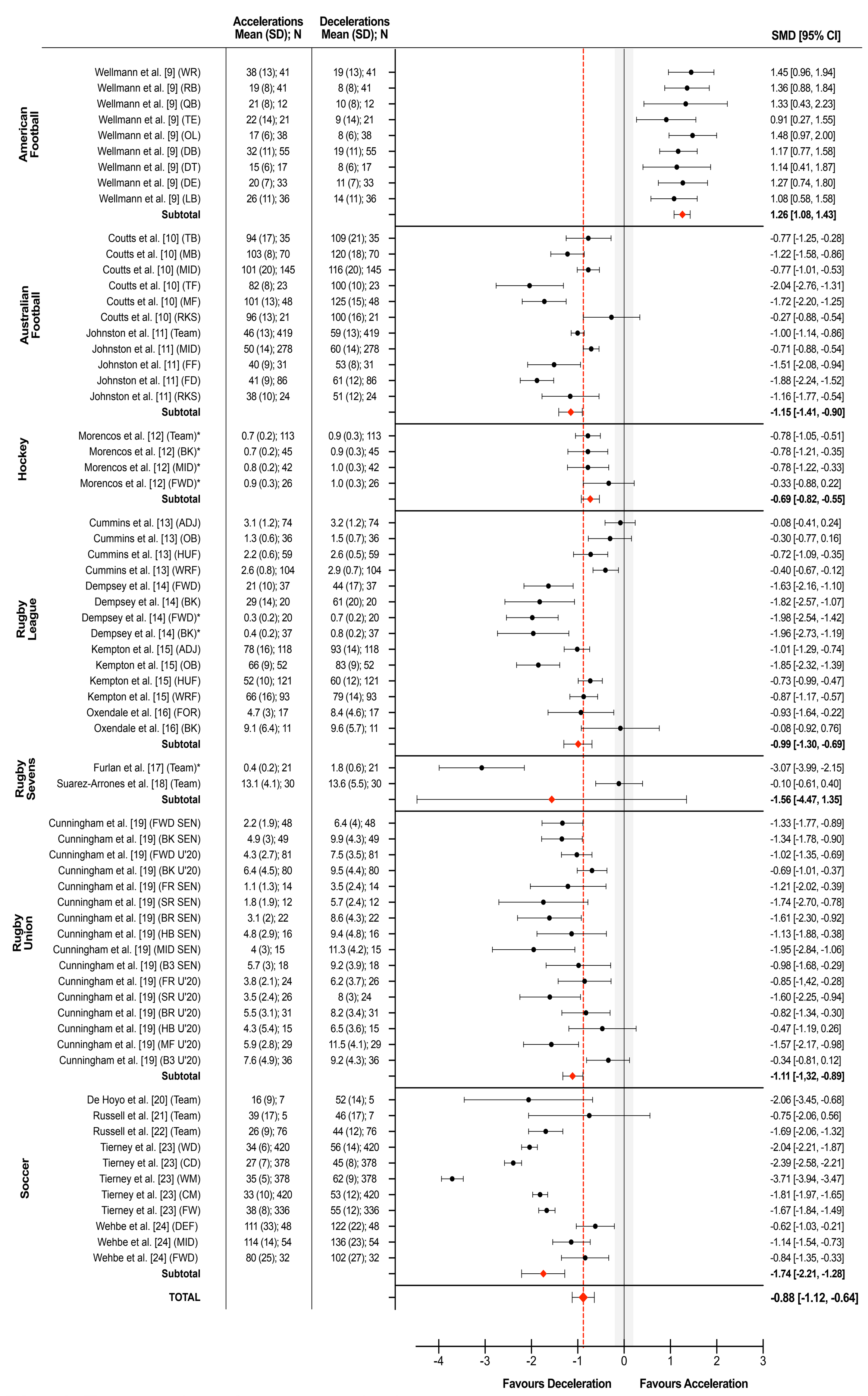


**Fig. 2** Forest plot of meta-analysis.
Single asterisk = Frequency relative to time (n.min$^{-1}$).

## RESULTS (continued)

- The greatest RoB (40% '*high*' RoB) observed across studies was in the 'data collection' procedures, with the lowest RoB (35% '*low*' RoB) found in the development of a 'normative profile' (see Fig. 2).

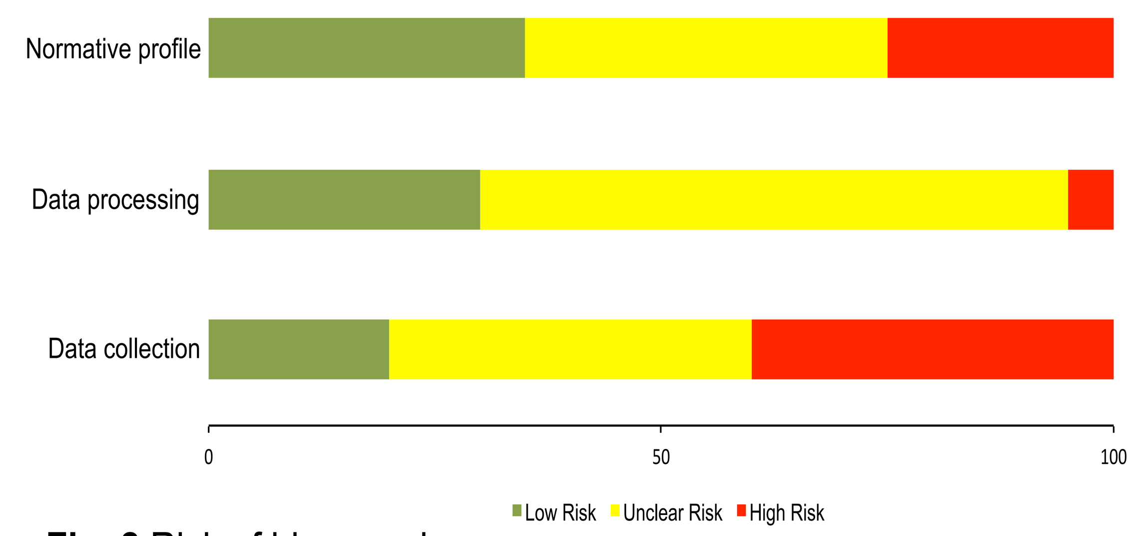


**Fig. 2** Risk of bias graph

## DISCUSSION

- With the exception of American football, the findings of our meta-analysis illustrate that elite players are exposed to more high-intensity decelerations than accelerations.
- High intensity decelerations comprise the highest magnitude of mechanical load per metre – reportedly up to 65% greater than any other match play activity and around 37% more than similarly intense accelerations [25].
- Even in elite players this load places a significant demand on the ability to repeatedly absorb high eccentric braking forces.
- High intensity decelerations are associated with muscle damage, deficits in neuromuscular performance capacity and psychological disturbances [20, 22, 24].
- An interesting finding of the present meta-analysis was that all positional roles in American football are required to perform more high intensity accelerations compared to decelerations - supports the significant time and investment that is placed on the assessment and development of an American footballer's rapid acceleration and top speed capabilities.
- Our review has also highlighted that there is currently a lack of consensus or consistency in the methodological procedures used to quantify high intensity accelerations and decelerations during match-play when using GPS devices.

## PRACTICAL APPLICATIONS

- Specific attention to loading strategies that can protect players from the damaging consequences of high-intensity decelerations are necessary [26].
- Practitioners should establish measurement procedures that allow for valid, reliable and precise information to be obtained on individual player high intensity acceleration and deceleration demands.
- All studies in this review used a 'generic' (i.e. $\geq$ 2.5 m.s$^{-2}$) threshold based approach to quantify high intensity acceleration and deceleration occurrences. In order to enhance training prescription future research should look to 'individualise' and 'contextualise' acceleration and deceleration outputs.

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# Validation of the Brzycki and Epley equations for female athletes.

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## Abstract

**Aim**: The purpose of this study was to investigate the validity of the Brzycki (1993) and Epley (1985) equations in predicting 1RM using 5RM and 10RM reps-to-fatigue loads in competitive female athletes.

**Methods**: 19 participants (mean ± SD age: 21 ± 1.7 years; weight: 65.95 ± 8.88 kg; height: 166.8 ± 5.09 cm) were tested on the Bench Press (BP) and Hex Bar Deadlift (HBDL) exercises. Following familiarisation participants were tested for 1RM, 5RM and 10RM values following NSCA guidelines with at least 48 hours in between tests.

**Results**: Statistical analysis revealed a strong positive correlation between all predicted 1RM values and actual 1RM ($r > 0.98$; $p < 0.01$) for BP. There was also a strong positive correlation between actual 1RM and all predicted 1RM values ($r > 0.95$; $p < 0.01$) for HBDL. Paired t-tests showed, that the Epley formula significantly overestimated actual 1RM ($p < 0.05$) when using 5RM reps-to-fatigue assessment in BP. There was also a significant difference between the Brzycki 10RM test compared to the achieved 1RM for the HBDL ($p < 0.05$). All other paired t-tests showed no significant differences between equation predicted 1RM and actual 1RM loads ($p > 0.05$).

**Conclusion**: The results of this investigation indicate that predicted 1RM values calculated from 5RM and 10RM submaximal loads using the Brzycki and Epley equations are highly correlated to actual 1RM values. This validation of predication equations will allow strength and conditioning coaches and researchers to assess predicted 1RM values when 1RM testing is impractical due to time or training experience constraints in competitive female athletes.

## Introduction

The one repetition maximum (1RM) test is the gold standard measure of assessing isotonic strength (Jimenez & De Paz, 2008; Mayhew et al., 2008; Brown & Weir, 2001; Abadie & Wentworth, 2000). Despite the value of measuring maximal strength with the 1RM test, this method is associated with inherent complications (Mayhew et al., 2008). Maximal testing can be time consuming and may require multiple spotters (Chapman et al., 1998) which can be difficulty when testing multiple athletes on a team. Although safe when performed correctly (Hamill, 1994; Mazur et al., 1993), lifting maximal loads can expose individuals to risk of injury (Chapman et al., 1998; Mayhew et al., 1992).

Several studies have validated the use of prediction equations with male participants, or with mixed samples (LeSeur et al., 1997; Nascimento et al. 2007). Mayhew et al. (2008, p.1571) raised concerns regarding the use of prediction equations for females as many of the currently available formulas "do not provide information on the population from which they were developed". To the authors knowledge no research has validated repetition maximum predication equations in female athletic populations.

## Aim

The aim of this investigation is to determine the accuracy of the Epley and Brzycki equations to predict 1RM from 10RM and 5RM tests in college-aged female athletes.

## Methods

19 participants (mean ± SD, age: 21 ± 1.7 years; weight: 65.95 ± 8.88 kg; height: 166.8 ± 5.09 cm) were tested on the Bench Press (BP) and Hex Bar Deadlift (HBDL) exercises. Following familiarisation participants were tested for 1RM, 5RM and 10RM values following NSCA guidelines with at least 48 hours in between tests.

Pearson product moment correlation coefficients (r) were used to evaluate the relationship between actual and predicted 1RM values. Paired t-tests determined the difference between estimated and actual 1RM scores. An alpha level of $p \leq 0.05$ was accepted for statistical significance. Constant error and percentage error determined for each estimation.

**Visit 1**
- **Familiarisation** of BP and HBDL and test procedures
- **Anthropometric** data

**Visit 2**
- **1 RM assessment**
  → 2 x w-up sets (8-10 reps @ ~50% 1RM; 3 reps @ ~70% 1RM)
  → All 1RMs achieved within 3-5 sets post w-up
  → 3-5 mins between sets
  → 0.5 - 5kg (BP) and 2.5– 7.5kg (HBDL) increments

**Visit 3 & 4**
- **5 RM or 10 RM assessment**
  → Random allocation
  → Same assessment procedure as 1 RM

## Equations

**Epley (1985):** 1RM = (0.033 * reps) * (load) + load

**Brzycki (1993):** 1RM = (load/ 1.0278) – (0.0278 * reps)

## Results

Analysis revealed a strong positive correlation between all predicted 1RM values and actual 1RM ($r > 0.98$; $p < 0.01$) for BP. There was also a strong positive correlation between actual 1RM and all predicted 1RM values ($r > 0.95$; $p < 0.01$) for HBDL. Paired t-tests showed that the Epley formula significantly overestimated actual 1RM ($p < 0.05$) when using 5RM reps-to-fatigue assessment in BP. There was also a significant difference between the Brzycki 10RM test compared to the achieved 1RM for the HBDL ($p < 0.05$).

**Table: Group Means; predicted vs actual 1RM**

| | | 1RM value | | CE | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | M | ±SD | M | % | *p* | *t* | *r* | *d* |
| Bench Press | 1RM | 38.6 | 7.61 | | | | | | |
| | Epley 5RM | 39.55 | 8.2 | -0.05 | 2.37 | 0.03* | 2.39 | 0.99** | 0.12 |
| | Epley 10RM | 39.37 | 7.87 | -0.04 | 2.04 | 0.11 | 1.67 | 0.98** | 0.1 |
| | Brzycki 5RM | 38.14 | 7.91 | 0.02 | 1.28 | 0.24 | 1.23 | 0.99** | 0.06 |
| | Brzycki 10RM | 39.38 | 7.88 | -0.04 | 2.14 | 0.11 | 1.7 | 0.98** | 0.1 |
| HB Deadlift | 1RM | 97.6 | 17.7 | | | | | | |
| | Epley 5RM | 99.1 | 16.8 | -0.08 | 1.48 | 0.07 | 1.94 | 0.98** | 0.08 |
| | Epley 10RM | 99.8 | 16.5 | -0.12 | 2.19 | 0.09 | 1.77 | 0.96** | 0.12 |
| | Brzycki 5RM | 93.9 | 17.3 | 0.19 | -3.8 | 0.09 | 1.78 | 0.86* | 0.21 |
| | Brzycki 10RM | 100.3 | 16.8 | -0.14 | 2.75 | 0.03* | 2.36 | 0.96** | 0.15 |

1RM= 1 repetition maximum, M= Mean, SD=Standard deviation, CE= constant error, %= percentage error, r= Pearson's correlation, d= Effect size, *p < 0.05, **p < 0.01

## Conclusion

This investigation indicates that predicted 1RM values calculated from 5RM and 10RM submaximal loads using the Brzycki (1993) and Epley (1985) equations are highly correlated to actual 1RM values. This validation of the predication equations will allow strength and conditioning coaches and researchers to assess predicted 1RM values when 1RM testing is impractical due to time or training experience constraints in competitive female athletes. The Epley (1985) formula yielded predictions for both lifts closer to actual 1RM values in this cohort. The Brzycki formula for HBDL at 10RM was the least accurate predictor.

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# Smaller head circumference and weak rotational neck strength are associated with increased concussion incidence

## An Analysis of the Relationship Between Head and Neck Circumference, Isometric Neck Strength and Concussion in School Boy Rugby Players, within a UK Independent School

Graham Williams[1] and Aaron Ryan[1]
[1]Millfield School, Millfield Institute of Sport and Wellbeing @MillfieldISW

### Introduction

- An understanding of the potential risk factors for concussion that present themselves
in this population may support more targ eted interventions.

**The purpose of this study:**

- Investigate the relationship between head and neck circumference, isometric neck strength and concussion occurrence in independent school rugby players.

### Method

- 58 males from years 9-13
- Head and neck circumference and isometric neck strength were assessed during the 2018-19 academic year.
- Isometric neck strength data were collected using a Mirco-fet 2 Dynometer.
- Subjects were assigned to concussion or non-concussion groups based on the occurrence of concussion in the 12-months period preceding data collection.

### Results

- Head circumference was *very likely greater* in the non-concussion group.
- Isometric left and right rotation strength was *likely greater* in the non-concussion group.
- There was a moderate positive relationship between head circumference and isometric strength in the concussion group (Fig. 1).
- There were strong positive correlations between isometric neck values in the non-concussion group (Fig.2).

### Practical application

- Neck training interventions to develop isometric rotation strength may have the potential to reduce concussion occurrence.
- Isometric rotation strength may be supported by the development of isometric strength through a variety of planes of motion.
- Head and neck isometric rotation strength could be utilised as a concussion risk screening tool.

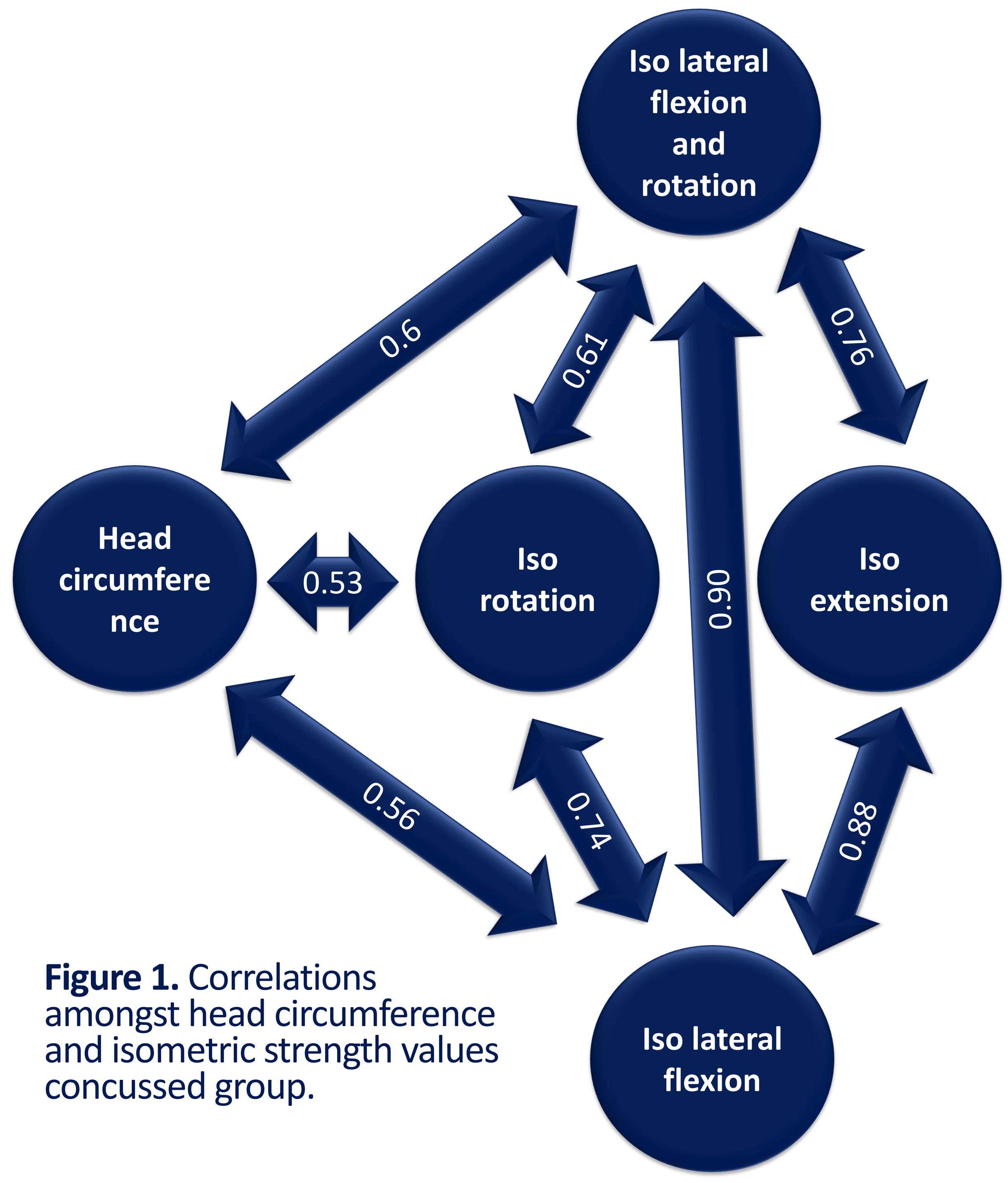


**Figure 1.** Correlations amongst head circumference and isometric strength values concussed group.

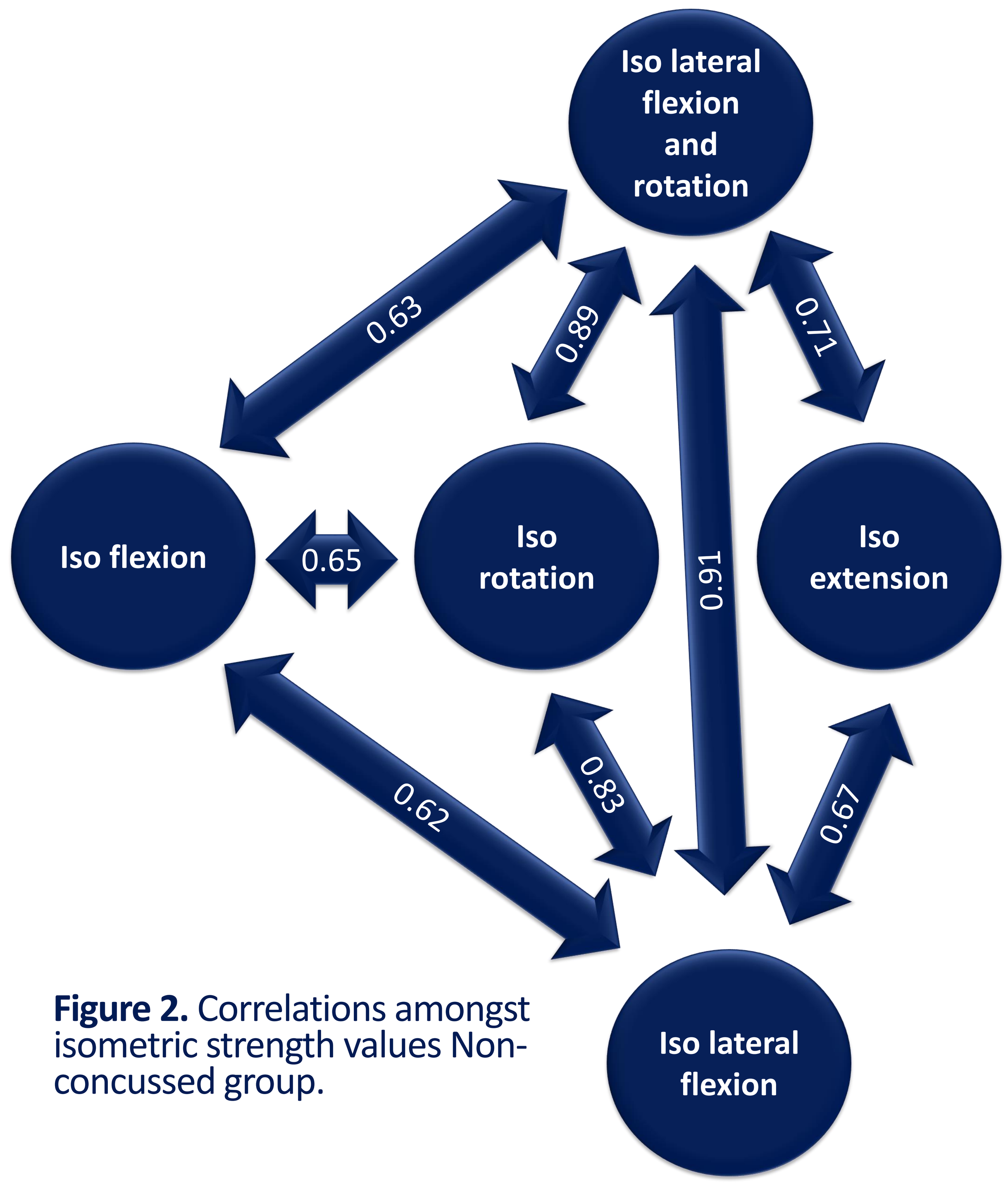


**Figure 2.** Correlations amongst isometric strength values Non-concussed group.

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MILLFIELD

MOLIRE MOLENDO

# Reducing perceived **psychological stress** in **youth athletes** *and* **sport science practitioners** may improve **readiness to perform**

## You Can't Pour from an Empty Cup: A Retrospective Analysis of Readiness and Wellness in Youth Athletes *and* Sport Science Practitioners in a Leading UK Talent Development Environment

Graham Williams[1] and Adam Greenslade[1]
[1]Millfield School, Millfield Institute of Sport and Wellbeing @MillfieldISW

## INTRODUCTION

- Subjective measures of training load may be able to reflect mental load (Coyne et al., 2018).
- Mental load appears to be an important moderator of training load's relationship with performance and injury (Smith et al., 2016).
- Literature has called for insight into the relationship between subjective measures (Coyne et al., 2018).

## METHODS

- Daily wellness and readiness to perform (RTP) logs were recorded via Metrifit (Health and Sport Technologies, Ltd) for 31 weeks.
- 98 youth athletes aged 15-18 years across 6 sports completed daily wellness logs.
- 8 practitioners across 2 sport science disciplines (S&C and physiotherapy) completed daily wellness logs .

## RESULTS

- Mean RTP for young athletes was 74.1% ± 1.8%.
- Mean RTP for practitioners was 78.4% ± 2.7%.
- RTP for the youth athletes was *most likely lower* compared to sport science practitioners (-1.63 ± 0.34).

## PRACTICAL APPLICATIONS

- Demographic specific interventions to enhance RTP youth athlete and sport science practitioners may be required.
- Interventions to decrease perceived psychological load in youth athletes may be advantageous – positive coping strategies, supportive social network.
- Interventions to decrease perceived biopsychological load in practitioners may be advantageous – safeguarding against work intensification, promoting sustainable careers.

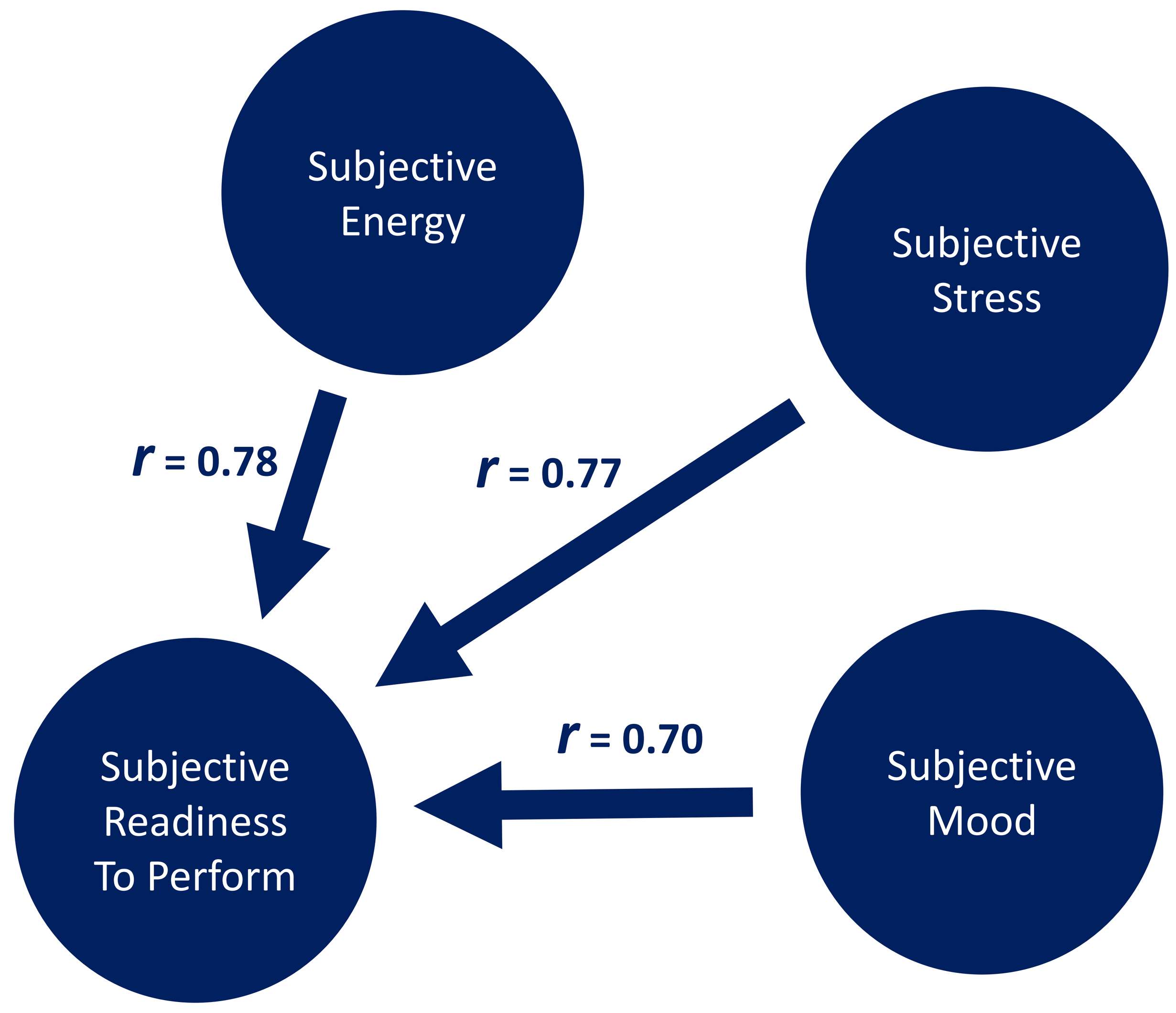


**Figure 1.** Correlation coefficient schematic for selected strong positive correlates of subjective readiness to perform in youth athletes.

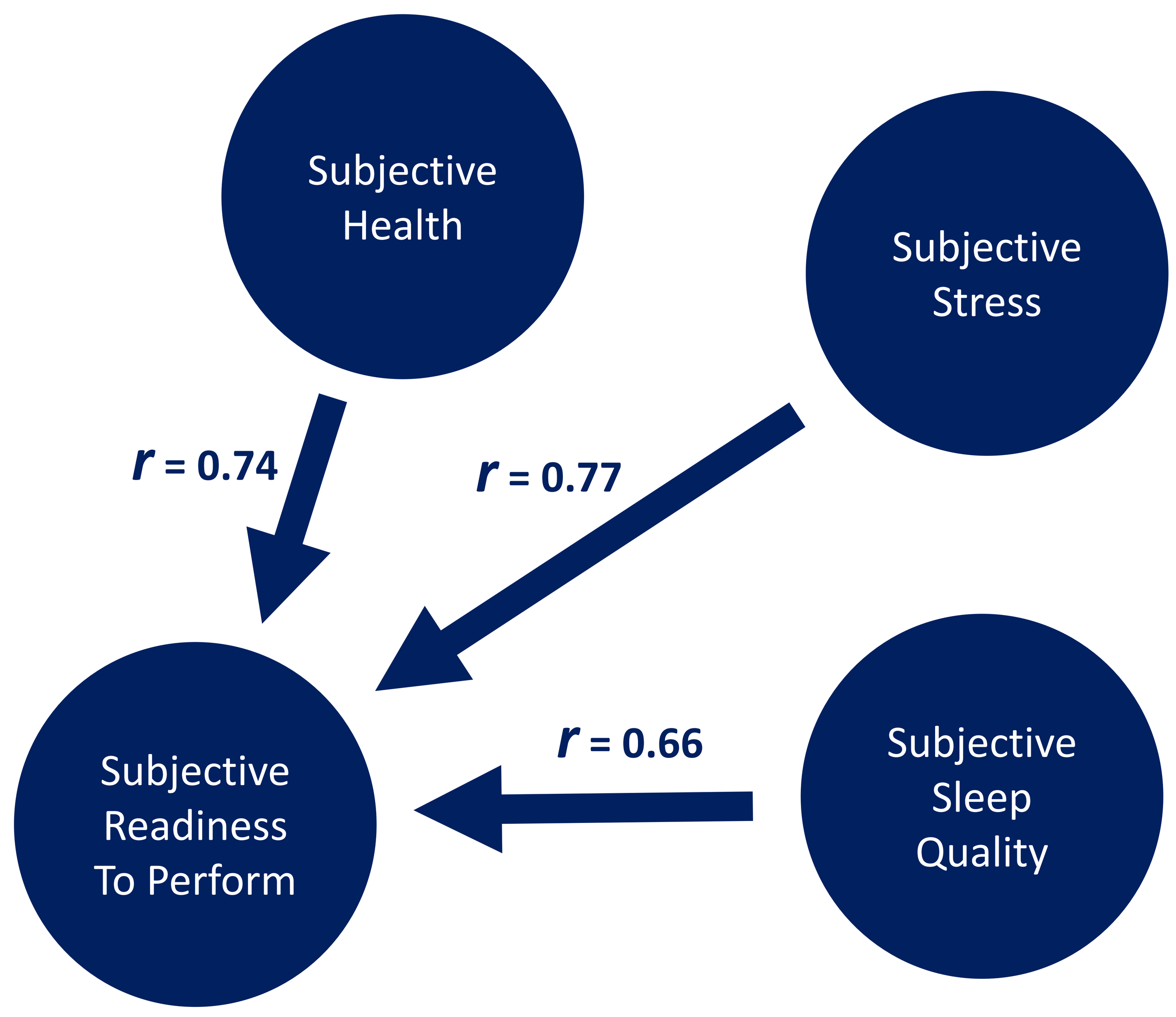


**Figure 2.** Correlation coefficient schematic for selected moderate to strong positive correlates of subjective readiness to perform in sport science practitioners.

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metrifit® are you ready to perform?

MILLFIELD

# The effect of resistance training interventions on 'the self' in youth: a meta-analysis.

Helen Collins [1,2], Samantha Fawkner[1], Josephine N Booth[1] & Audrey Duncan[2]

[1] *University of Edinburgh, UK*
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University of Dundee

## BACKGOUND

- There is growing evidence that physical activity (PA) is beneficial for the mental health of young people (Dale *et al*., 2019).
- One area that has been widely examined is the impact of PA on 'the self' (Biddle *et al.,* 2018).
- 'The self' is a term that encompasses a range of specific and related terms (e.g. self-esteem, self-efficacy, self-perceptions).
- There is evidence that PA is strongly associated with 'the self' in childhood and beyond.
- However, despite positive endorsement of resistance training (RT) in both the PA guidelines and NSCA and UKSCA position statements, the evidence to support a positive effect of isolated RT on 'the self' remains inconclusive.

## AIM

The purpose of this meta-analysis was to advance knowledge on the potential for RT to enhance mental health by examining the effect of isolated RT interventions on 'the self' in youth.

## METHODS

- Titles of potentially relevant articles were retrieved using a comprehensive search strategy, duplicates removed, and then the titles and abstracts were screened.
- Identified relevant references from published literature were included where they met the inclusion criteria. Figure 1 illustrates the PRISMA flow diagram.
- Data was extracted using an electronic form and the "Quality Assessment Tool for Quantitative Studies", developed by the Effective Public Health Practice Project (EPHPP) in 1998, was used to assess the quality and risk of bias of the included studies.
- Mean, SD and sample size data was extracted and random effects meta-analyses (Hedges' g with a 95% CI) were performed using 'Comprehensive Meta-analysis' software.

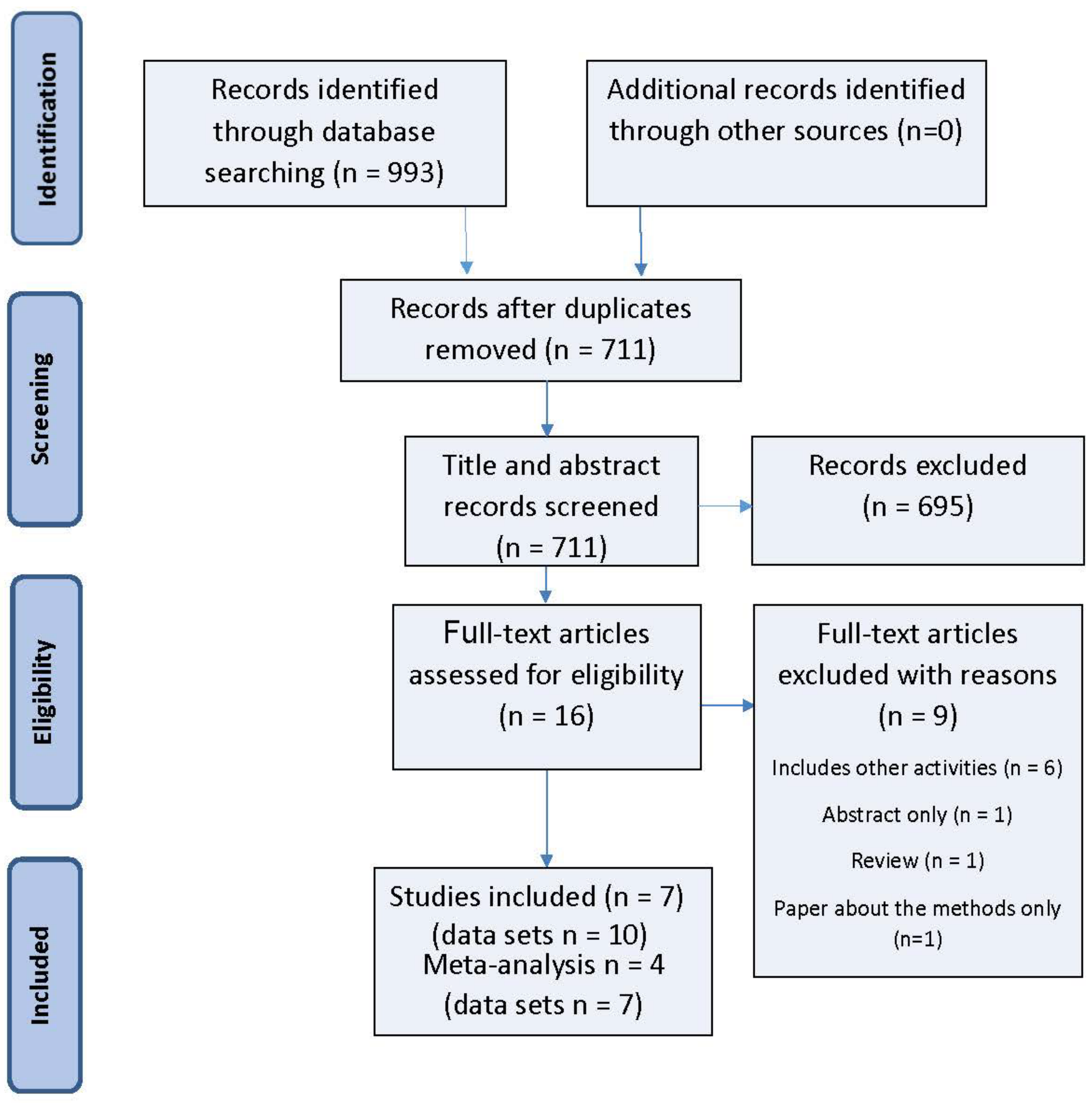


*Figure 1. PRISMA flow diagram*

## RESULTS/DISCUSSION

- From seven peer reviewed studies, ten data sets were included exploring seven outcomes related to 'the self' in participants aged between 10-16 years.
- Four of these studies (including seven data sets) were combined in a meta-analysis.
- Significant intervention effects were identified for: resistance training self-efficacy (Hedges' g = 0.538, 95% CI 0.254 to 0.822, P < 0.001), perceived physical strength (Hedges' g = 0.289, 95% CI 0.067 to 0.511, P = 0.011), physical self-worth (Hedges' g = 0.319, 95% CI 0.114 to 0.523, P = 0.002) and global self-worth (Hedges' g = 0.409, 95% 0.149 to 0.669, P = 0.002).
- There was variable quality of studies, with just two studies being classified as 'strong'.
- This is the first review to synthesise research on the effects of isolated RT interventions on 'the self'.
- Exploring the possible mechanism behind all of the significant findings, the EXSEM model (Sonstoem & Morag, 1989) may provide an explanation.
- The model proposes that perceived physical competencies developed through exercise, including RT, can enhance global self-esteem.
- This would support the current finding that RT had a positive effect on physical self-worth, physical strength and resistance training efficacy which subsequently may have also had a positive effect on global self-worth.

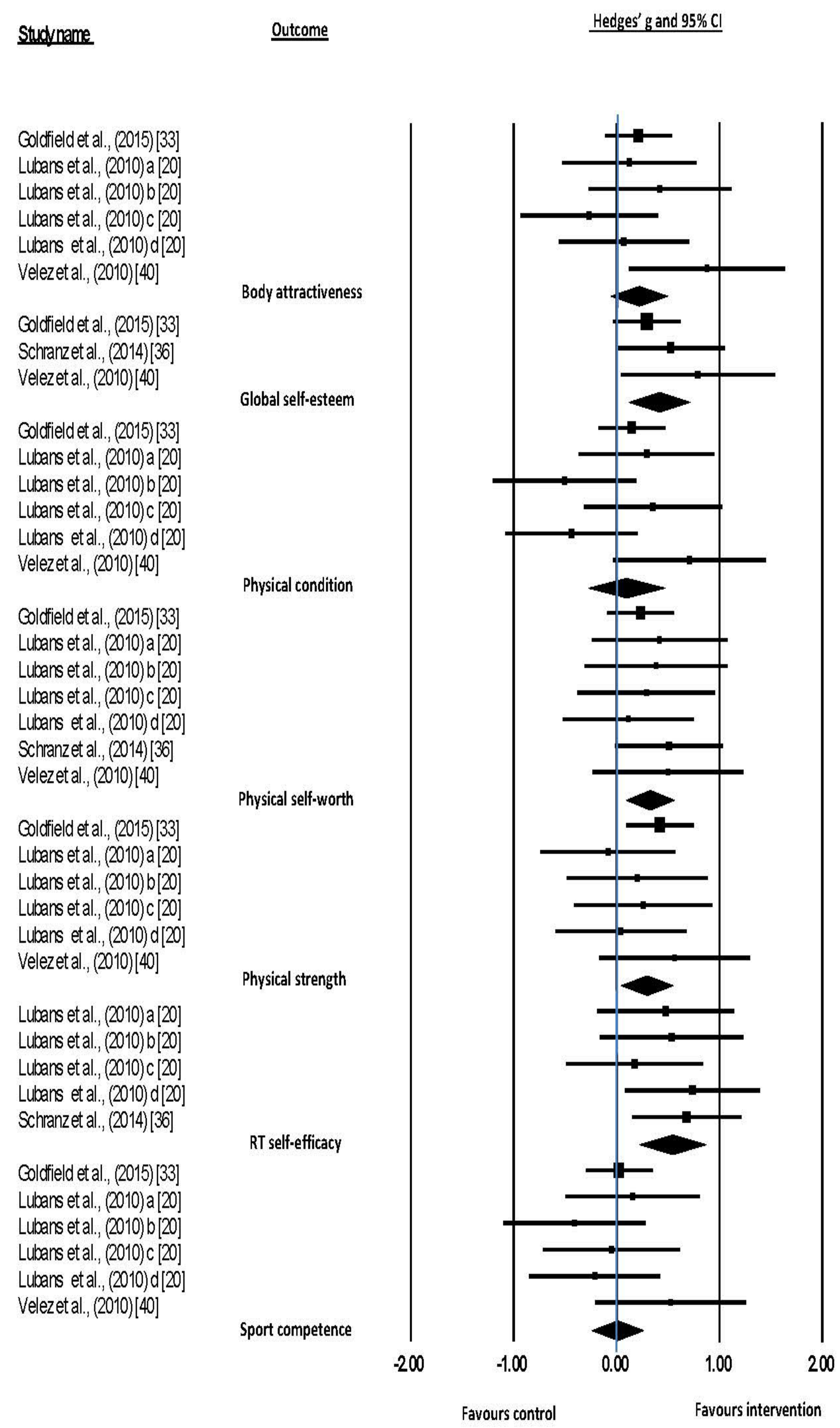


*Figure 2. Forest plot of meta-analyses*

## CONCLUSION

- The findings indicate that RT has a positive impact on some aspects of 'the self' in youth.
- More high quality studies should be conducted to further investigate this topic.
- If validated, this type of intervention could offer an alternative intervention approach to improving the mental health of individuals, not only during childhood but as they progress through life.


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# U18 school netballers **accelerated** and **decelerated more** and **travelled less distance** compared to U14 netballers

## What does it take to transition? Match demands of mid court players in netball across different age groups in an independent school setting

James So[1] and Graham Williams[1]

[1]Millfield School, Millfield Institute of Sport and Wellbeing @MillfieldISW

## INTRODUCTION

- Netballers transitioning to higher standards of competition need to develop physical qualities to meet the match demands
- Similarity in the positional demands of mid court players in netball due to court restrictions (Thomas et al., 2017)
- The aim of the study was to investigate the mid court demands between different year groups to better optimise training and performance

## METHODS

- Data from 3 matches across 3 year groups in the 2018/2019 school year were collected via PlayerTek GPS units
- Mid court positions chosen included centre, wing attack/defence, goal attack/defence
- Data analysed via magnitude-based inferences, with activity profiles for each year group compared against each other
- Activity profiles centred on distance per minute, acceleration and deceleration count in different speed zones for each quarter

## RESULTS

### Distance per Minute

- U18 showed a *likely lower* distance per minute than U14

### Acceleration & Deceleration Count

- U18 showed a *very likely higher* acceleration and deceleration count at > 4 $m.s^{-2}min^{-1}$ compared to U14
- U16 demonstrated a *likely lower to very likely lower* acceleration and deceleration count in all speed zones compared to U14

## PRACTICAL APPLICATIONS

- Netball coaches should be aware of the unique match play demands within this demographic.
- At advanced age groups, development of maximum concentric and eccentric force production, acceleration and deceleration profile, and anaerobic energy system conditioning may be advantageous.
- At junior age groups, early introduction into developing effective movement skills and the expression of force may be warranted.

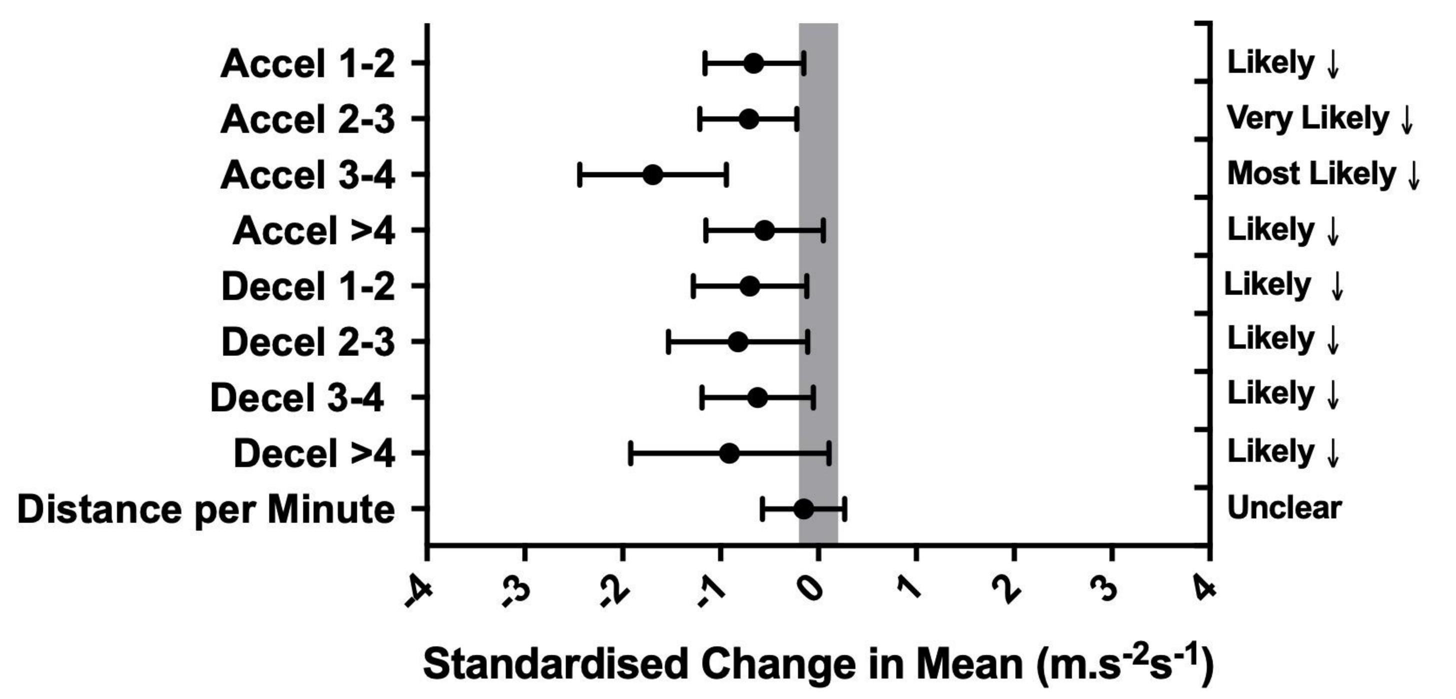


**Figure 1**. Comparison of activity profiles between U16 vs U14 netballers . Data represented as standardised change in mean (± 90% CI) with MBI's

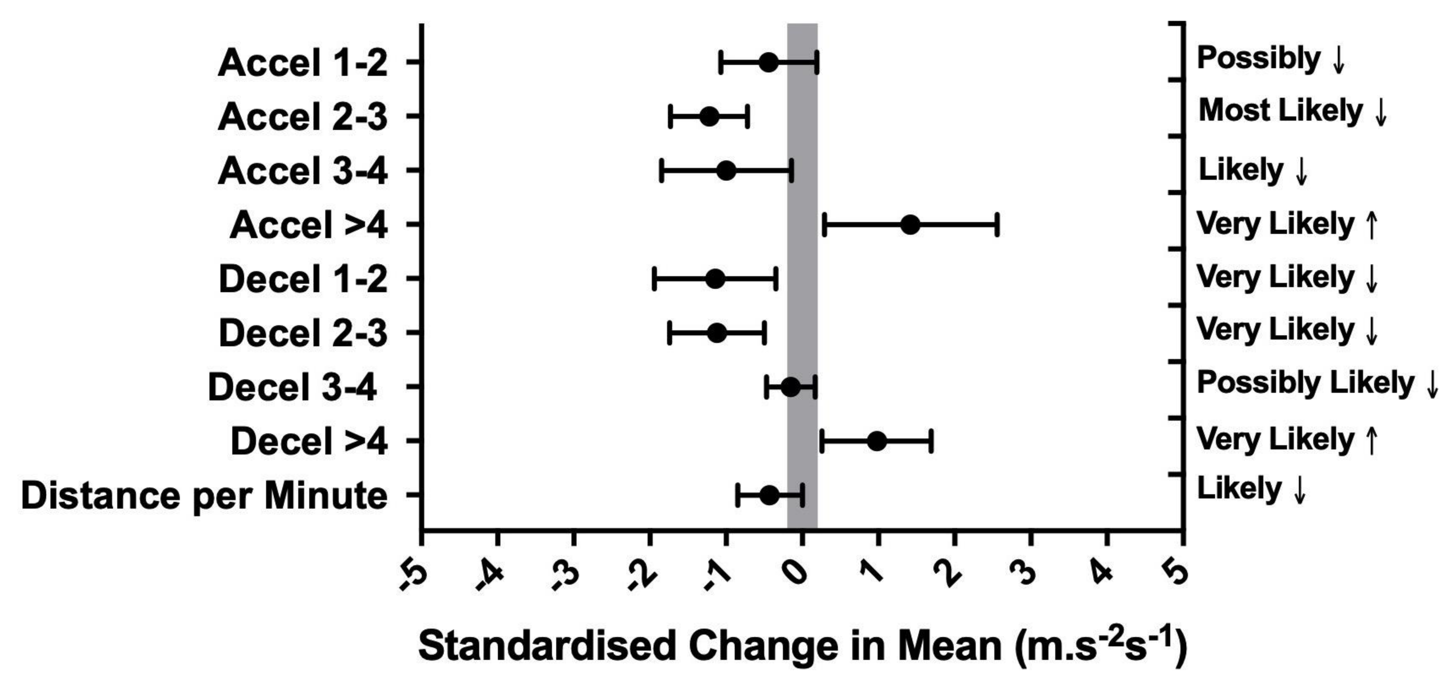


**Figure 2.** Comparison of activity profiles between U18 vs U14 netballers . Data represented as standardised change in mean (± 90% CI) with MBI's

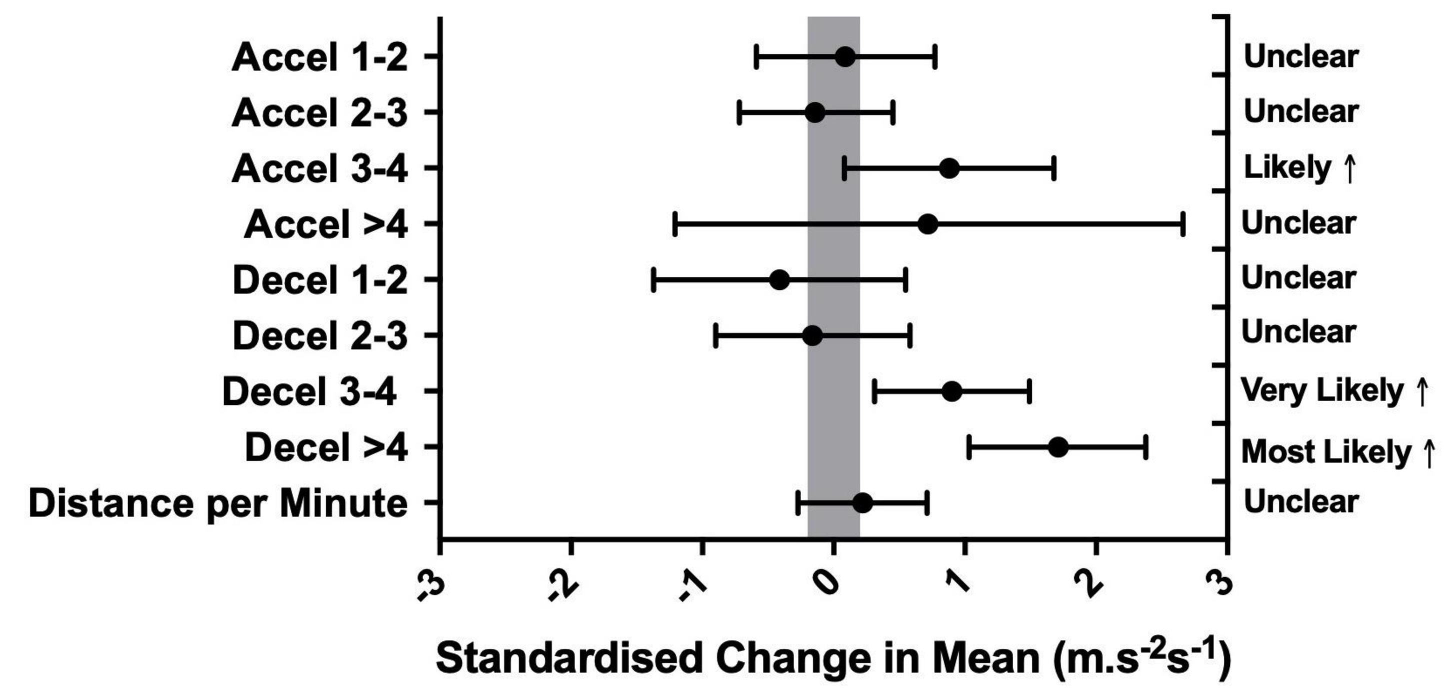


**Figure 3.** Comparison of activity profiles between U18 vs U16 netballers . Data represented as standardised change in mean (± 90% CI) with MBI's

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MILLFIELD

# Effects of Varying Inertial Loadings on Power Variables in the Flywheel Romanian Deadlift Exercise

**Joey O Brien, Declan Browne, Des Earls**
HealthCore, Department of Science, Sport and Health, Institute of Technology Carlow

Institiúid Teicneolaíochta Cheatharlach
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## Introduction

Flywheel devices were designed to provide resistance by the inertial force generated by rotating flywheels during acceleration (concentric) and breaking (eccentric) movement phases (Sabido et al. 2018). This inertial force is reliant on the diameter, thickness and density of the flywheel while also depending on the acceleration generated by the athlete (Piqueras-Sanchiz et al., 2019). In contrast to traditional resistance training exercises flywheel training may produce greater force during the eccentric phase than in the concentric phase which leads to an eccentric overload (Martinez-Aranda and Fernandez-Gonzalo, 2017).

The purpose of this intervention was to investigate the effects of different inertial loadings on power variables during the flywheel Romanian deadlift and identify an optimal loading to maximise desired response


## Methods

Fourteen recreationally trained males (27.9 ± 6.4 years, 90 ± 10.7 kg, 180.7 ± 5.5 cm) participated in the study. All participants performed 4 sets of 12 repetitions of the Romanian deadlift exercise performed on a flywheel device (kBox 3, Exxentric, AB TM, Bromma, Sweden). Each set was performed using different inertia loads, these being 0.025, 0.050, 0.075 and 0.100 kg·m². The order of the internia load setting was randomised for each participant. A 5 minute inter-set rest period was given. During each repetition power was recorded by means of a data reader and transmitter (Kmeter, Exxentric, AB TM, Bromma, Sweden) attached to the flywheel device.



## Results

**Table 1: Average Power, Peak Concentric Power, Peak Eccentric Power and % Eccentric Overload during different inertia loads (Mean ± SD)**

| | Internia in kg·m2 | | | |
|---|---|---|---|---|
| | **0.025** | **0.05** | **0.075** | **0.1** |
| **AVG** | 757.43 ± 529.53 | 598.12 ± 270.86 | 517.26 ± 139.69 | 475.83 ± 134.39 |
| **CON Peak** | 1120.35 ± 530.53 | 947.75 ± 380.96 | 800.42 ± 201.23 | 728.08 ± 192.23 |
| **ECC Peak** | 1050.13 ± 425.15 | 1033.59 ± 406.80 | 880.92 ± 227.84 | 817.13 ± 206.27 |
| **% OL** | - 0.16 ± 31.55 | 9.82 ± 10.85 | 10.41 ± 12.66 | 13.8 ± 12.66 |

AVG=Average Power, CON Peak = Peak Concentric Power, ECC Peak = Peak Eccentric Power, % OL = % Eccentric Overload

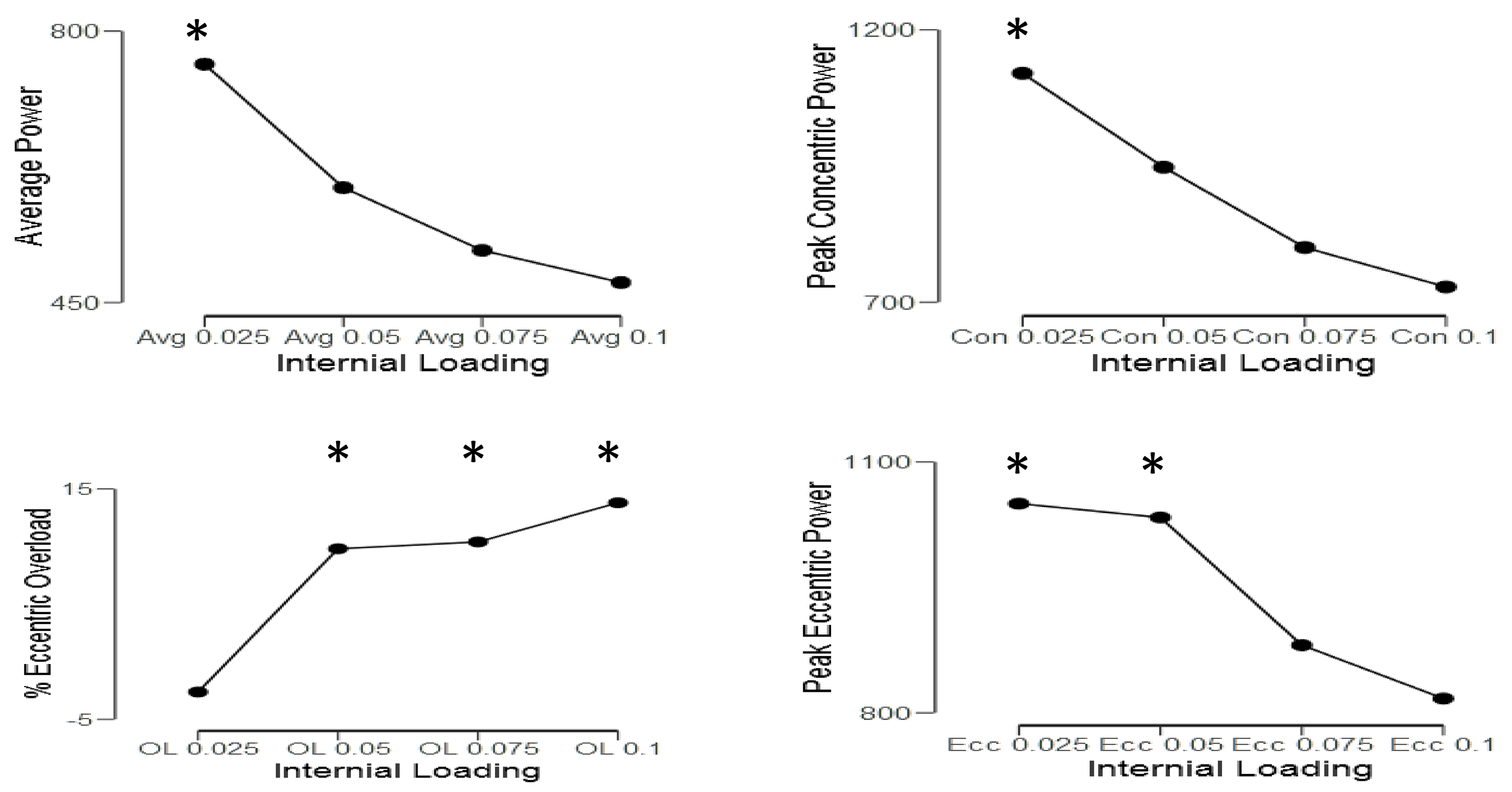


**Figure 1: Average Power, Peak Concentric Power , Peak Eccentric Power & % Eccentric Overload (W) within varying Inertial Loads * Denotes statistically significantly greater difference**

## Discussion

- This study established that lower inertial loads lead to higher average, peak concentric and peak eccentric power values.
- Specifically, the 0.025 kg·m² load led to greatest values.
- The results show that the lightest load (0.025 kg·m²) displayed significantly lower eccentric overload values when compared to greater loads (0.050, 0.075 and 0.100 kg·m²).
- Moderate to high inertial loads lead to similar eccentric overload values.
- Lighter loads may be optimal for maximum power in the flywheel Romanian deadlift exercise.
- Moderate to heavy inertial loadings (0.050, 0.075 and 0.100 kg·m²) will lead to significant eccentric overload in the flywheel Romanian deadlift exercise.
- Participant strength may have been a limiting factor and warrants future research.

## References

Martinez-Aranda, L. M. and Fernandez-Gonzalo, R. (2017) 'Effects of inertial setting on power, force, work, and eccentric overload during flywheel resistance exercise in women and men', *Journal of Strength and Conditioning Research*, 31(6), pp. 1653–1661.
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**ACKNOWLEDGEMENTS**
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UKSCA

# Younger school footballers may benefit from aerobic development, older players require high-speed and anaerobic development

## What Does It Take to Transition? Movement Demands of Football Match Play Amongst Under 14, U15, U16 and U18 Age Groups in an Independent School


Liam Bagge[1] and Graham Williams[1]

[1]Millfield School, Millfield Institute of Sport and Wellbeing

@MillfieldISW


### Introduction

- The physical demands of football and its development across chronological age groups have not been explored in school sport
- The purpose was to identify how to best support the successful transition of youth, male footballers as they transition through academic year groups.
- To analyse the competitive match play demands of football in an independent school across U14, U15, U16 and U18 age groups.

### Method

- 25 male football players- Years 9-13
- 5 matches monitored over the 2018-19 year
- 
- Five players from each age group were randomly selected to wear GPS (Playertek, Catapult)

**Metrics assessed:**

- Average Distance per Minute (m/min)
- Average Sprint Distance (m)
- Maximum Velocity (m/s)

### Results

**Average Distance per Minute (m/min)**

- U14 was *most likely greater* compared with U16, 2nd X1 and 1st XI and *likely greater* than U15 (Figure 1)

**Average Sprint Distance (m)**

- Sprint distance was *likely higher* in U14 than U16 and *unclear* VS U15, 2nd XI and 1st XI (Figure 2)

**Average Maximum Velocity (m/s)**

- Max velocity was *likely greater* in 1st XI than U14 (Figure 3)

### Practical Application

- At a more junior level, the development of the aerobic energy system may be warranted given the extensive match play demands
- More advanced chronological year groups may require the physical development of high-speed movement and anaerobic energy system development relative to playing position demands.

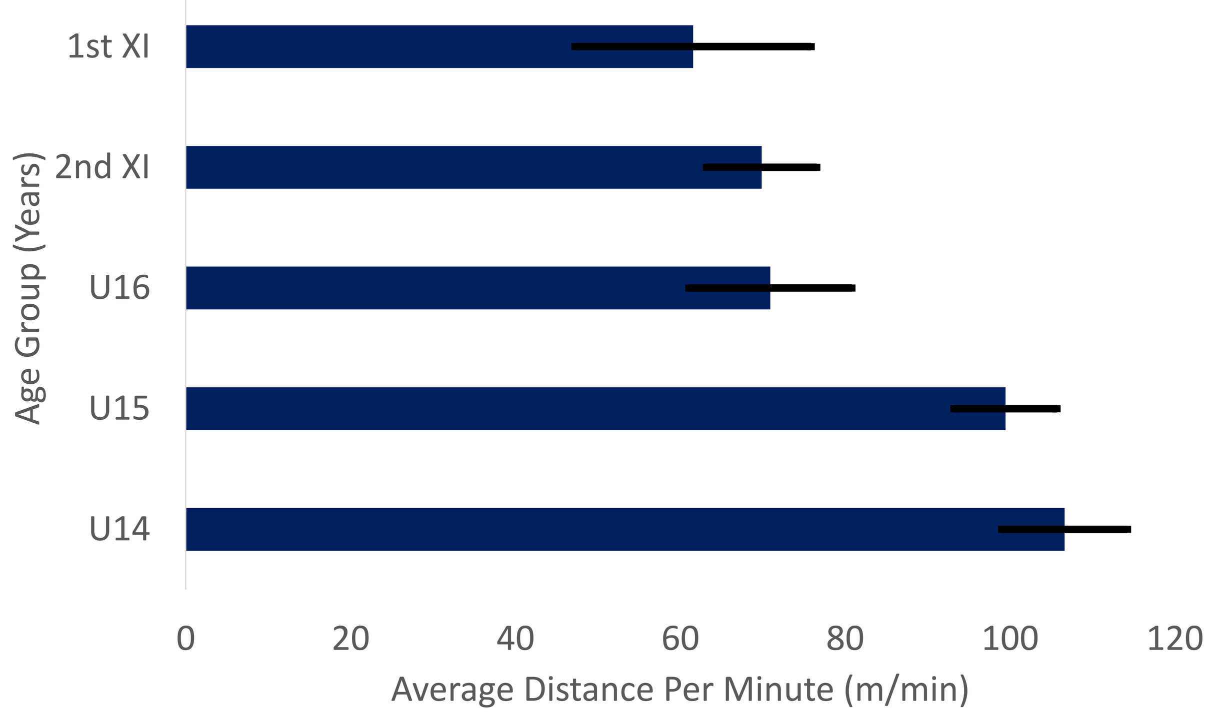


**Figure 1**. Comparison of average distance per minute (m/min) across age groups

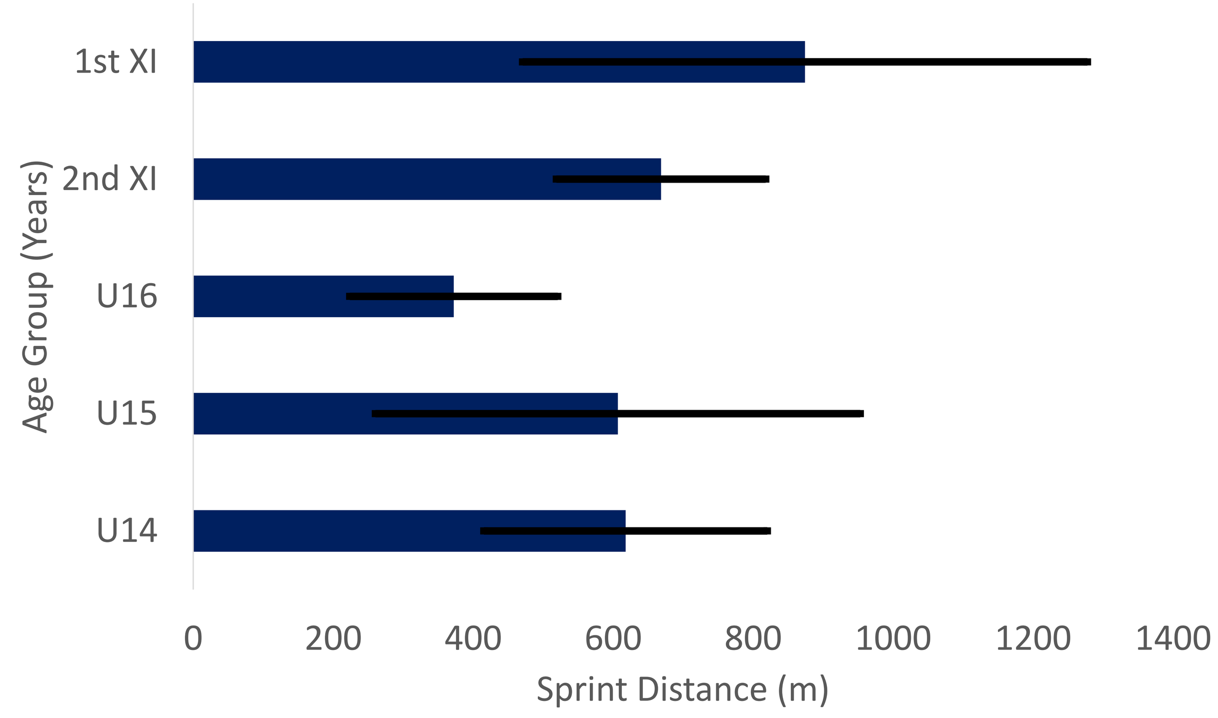


**Figure 2.** Comparison of average sprint distance (m) across age groups

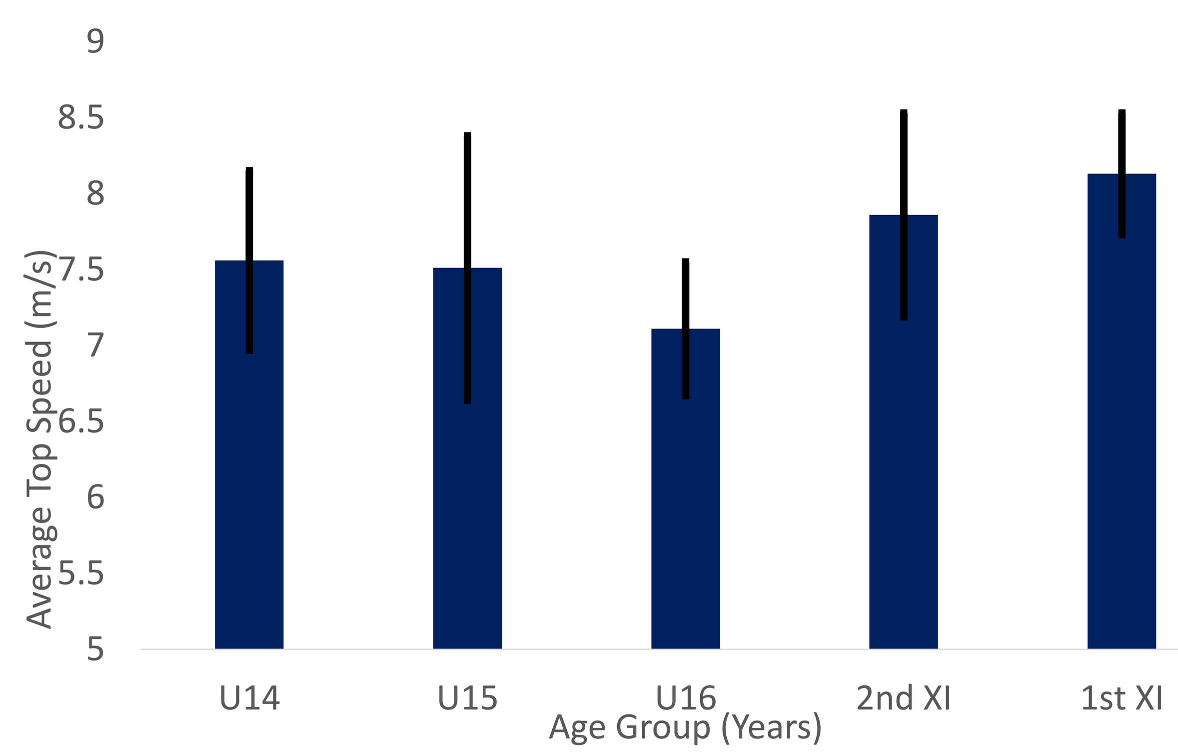


**Figure 3.** Comparison of average maximum velocity (m/s) across age groups

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MILLFIELD

# Hamstring strength asymmetries in academy cricketers: the impact of training throughout a pre-season

Luke Taylor, John Harman, John Jakeman and Maximillian Honigsbaum
Oxford Brookes University

## Introduction

The aim of this study was to assess the levels of hamstring asymmetry across multiple tests in male English University Academy (MCCU) cricketers and assess the impact of training during the 2018-19 pre-season, and measuring any differences across playing position.

Muscular asymmetry can impact injury risk and physical performance across various sports and actions, with recent research suggesting that this may be a sport specific adaptation to functional performance (Gray *et al*., 2016). Fast bowlers are known to be at a heightened injury risk due to the ballistic nature of their action compared to other roles within cricket with batsman being another position identified as at risk. This case study looked to assess the levels of asymmetry across playing position in hamstring strength and capacity.

## Methods

Three testing sessions during pre-season (30 weeks) were taken to assess the impact of training and overall development. The following measurements were taken from Nordboard assessments; absolute peak force (N) left and right legs. Furthermore, a single leg hamstring bridge capacity assessment was tested to assess muscular capacity in both left and right legs.

Athletes were grouped by broad specialty into spin bowlers (n = 5), fast bowlers (n = 9) and all-rounder/ batsmen (n = 10). The S&C programme lasted 30 weeks, with an average of 5 S&C sessions each week. Each strength training session had elements of hamstring work within the session either eccentric or isometric in focus or both. Furthermore, alongside sprint mechanic development, athletes were exposed to max velocity work throughout preseason.

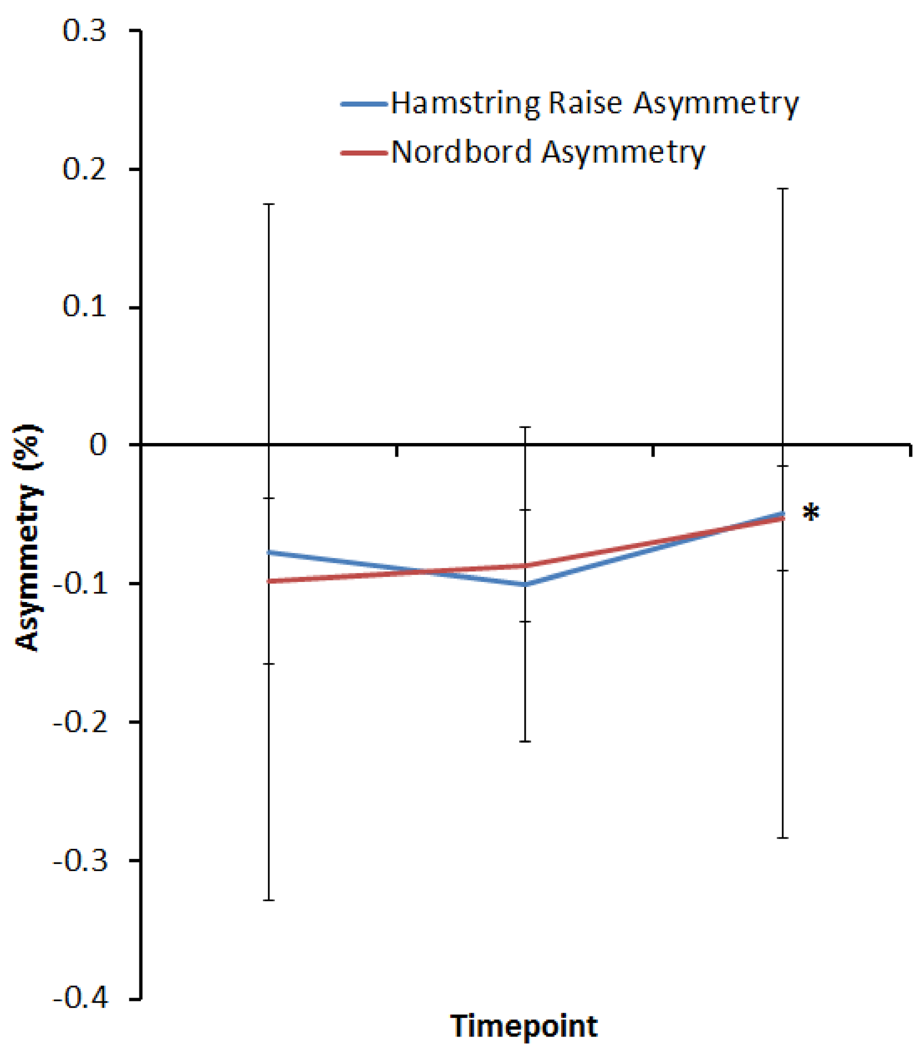



Figure 2.

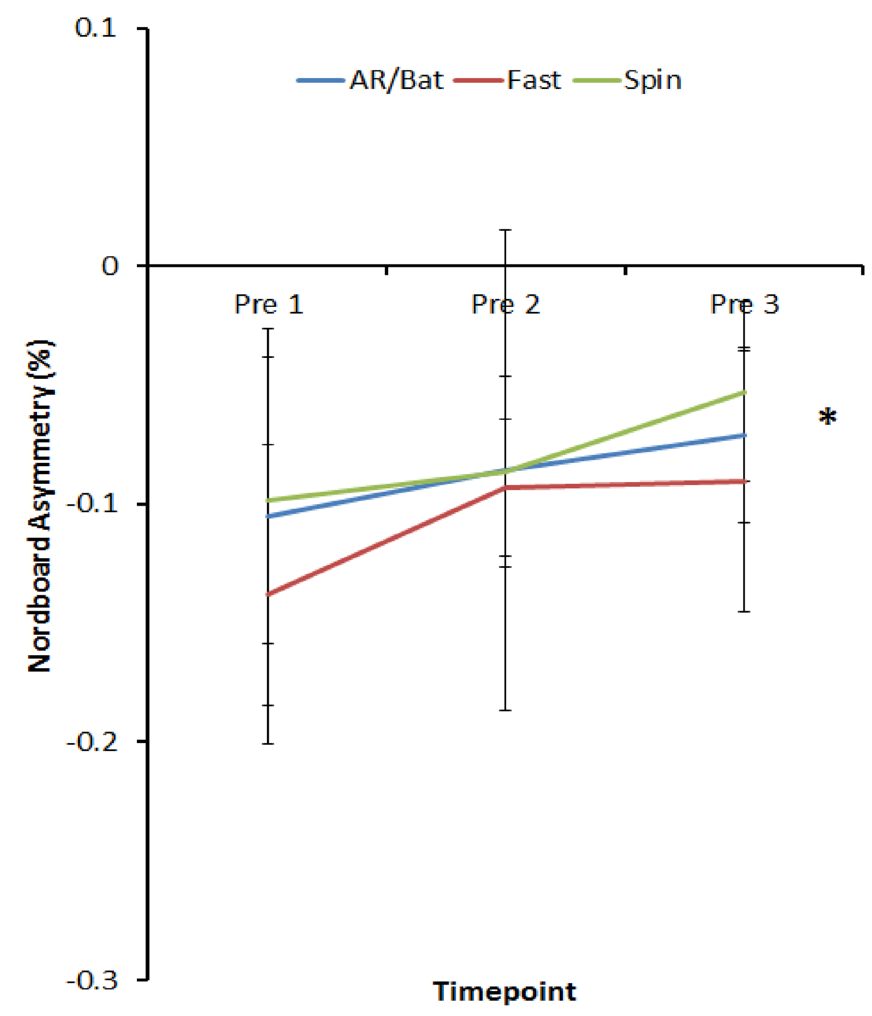



Figure 3.

## Results

There were significant improvements in absolute strength for all players in both left (+14.4% (±16.9%)) and right (+18.4% (±18.6%)) legs, assessed with the hamstring bridge (Fig. 1A), and assessed with the Nordboard (left + 9.9% (±5.8%), right + 5.9% (±3.3%); Fig. 1B)). The Nordboard indicated a small, but statistically significant improved symmetry (reduced asymmetry) over the three testing sessions (0.04% (±0.01%) Fig. 2), but the same effect was not observed using the hamstring bridge. Interestingly, while the pattern of asymmetry improvement was generally linear in the spin and all-round/batsmen groups, there was a plateau in improvement in the fast bowler group between the second and third time points (Fig. 3).

## Summary and Conclusions

This case study shows the impact of targeted hamstring strength training over the course of a pre-season to create a lower level of hamstring asymmetry prior to the competitive season commencing. The lack of improvement in symmetry between time point 2 and 3 within the fast bowler group is not surprising and falls inline with previous research suggesting asymmetry being a sport specific adaptation to the task of delivering a fast ball. The practitioner must be conscious of this adaptation and understand that guidelines indicating injury risk may not be relevant to all sporting populations. Decisions based on these findings must be applied in a case by case basis taking into account the athletes; sport, position and injury history in addition to their physical outputs. Additionally, establishing the dominant limb prior to an intervention may allow the practitioner to develop targeted programmes for specific asymmetries. This case study will continue to assess whether the increase of bowling workload, particularly in the fast bowling unit, will induce a new hamstring asymmetry favouring the landing leg during the delivery stride.

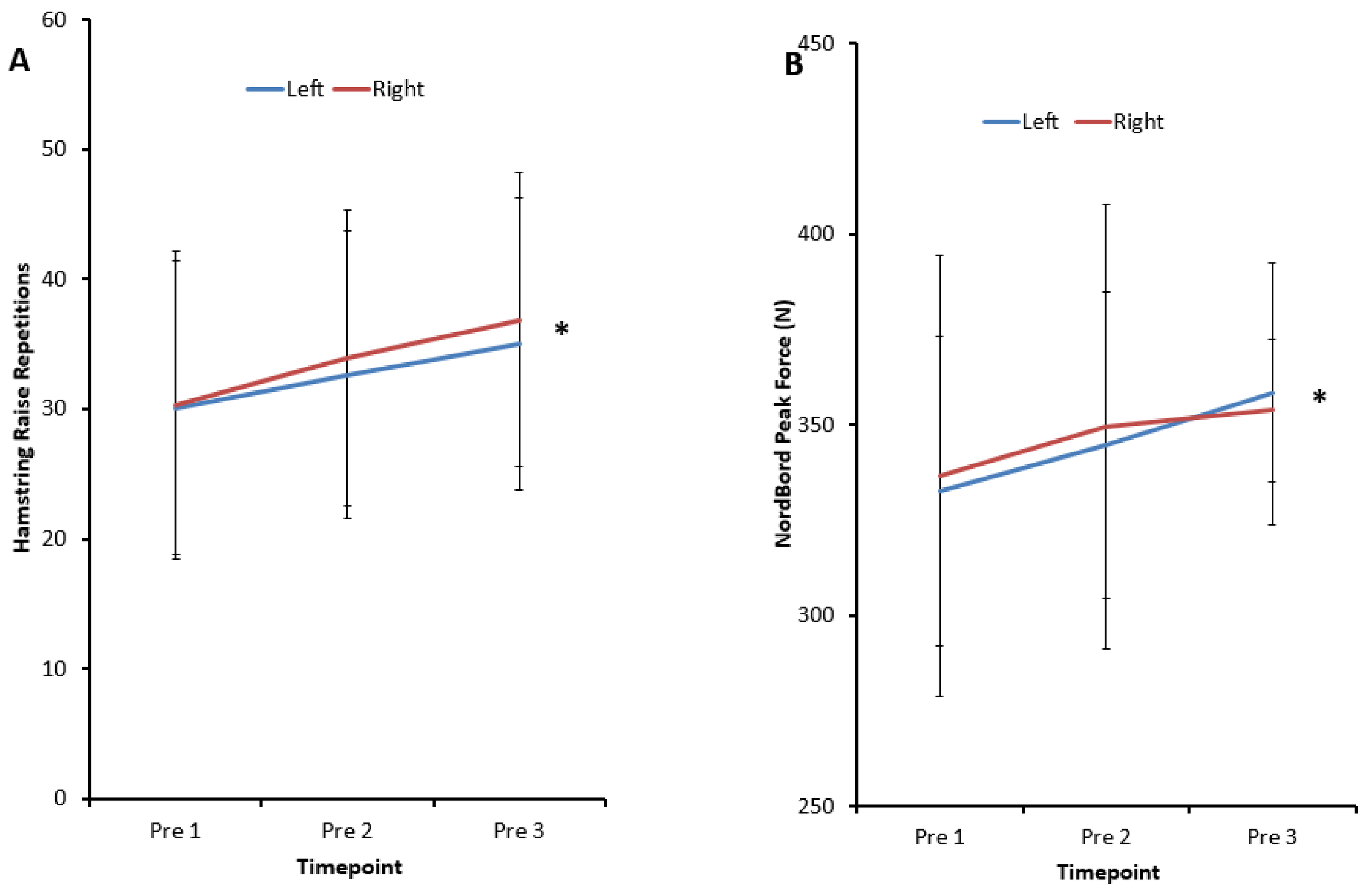
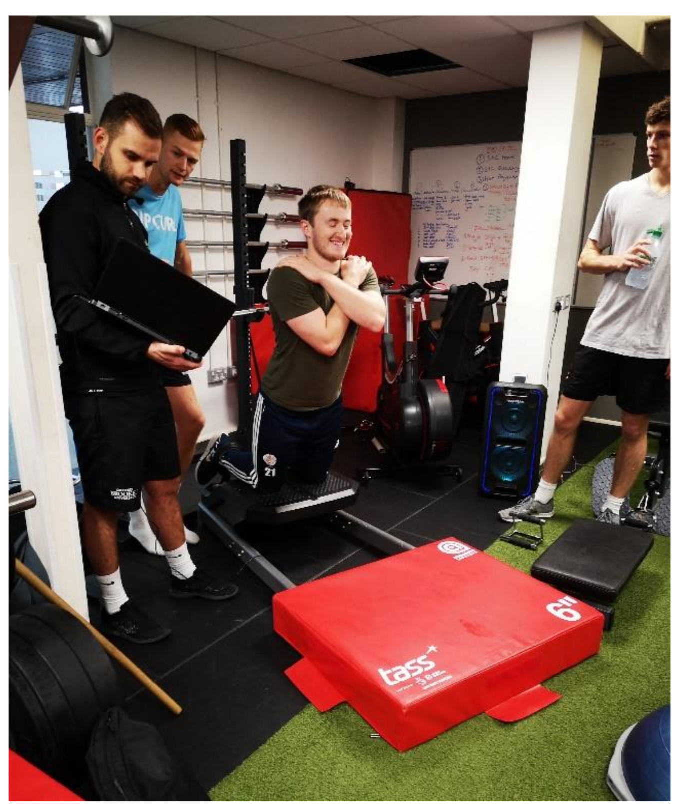



Figure 1.



OXFORD BROOKES UNIVERSITY

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# A Kinetic and Kinematic Analysis of The Rear Foot Elevated Split Squat 5RM Test

Mark Helme, Dr Stacey Emmonds, Dr Chris Low[1]

[1] Institute of Sport, Physical activity and Leisure, Carnegie School of Sport.

Mark.helme@leedsbeckett.ac.uk

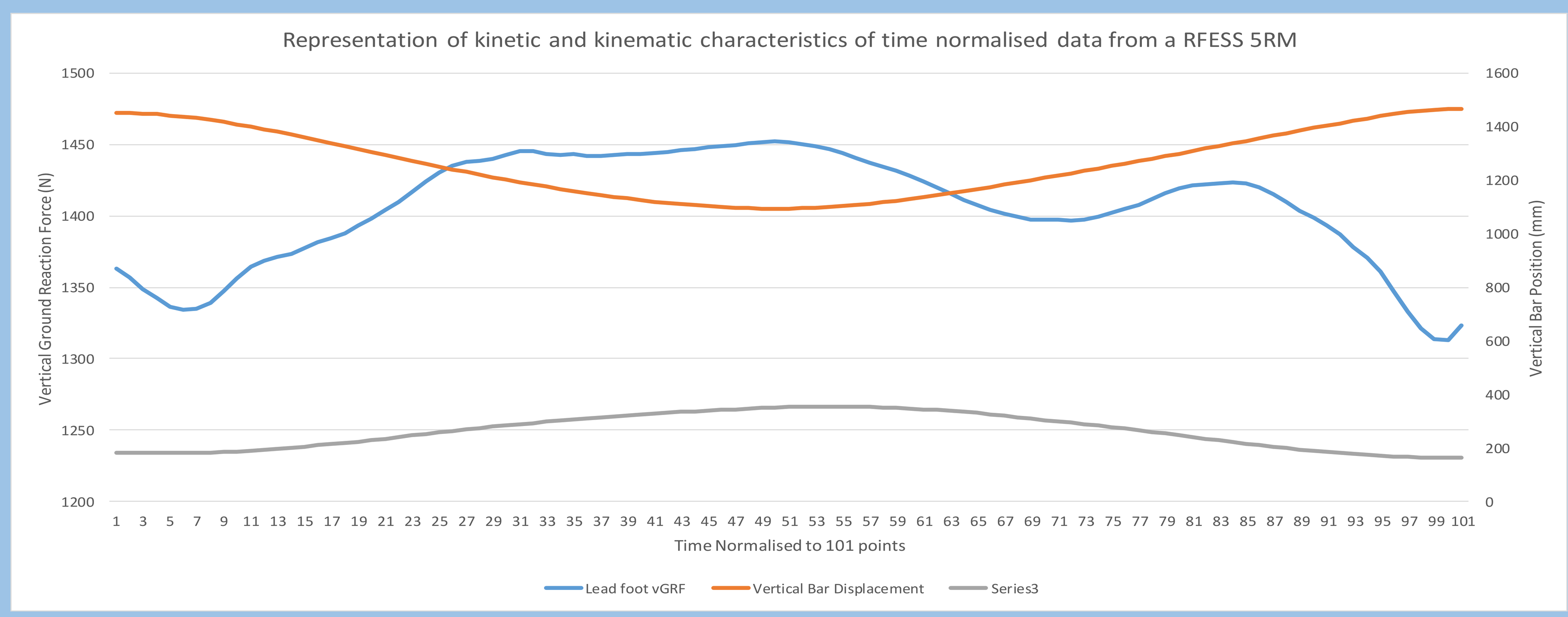
**Introduction**

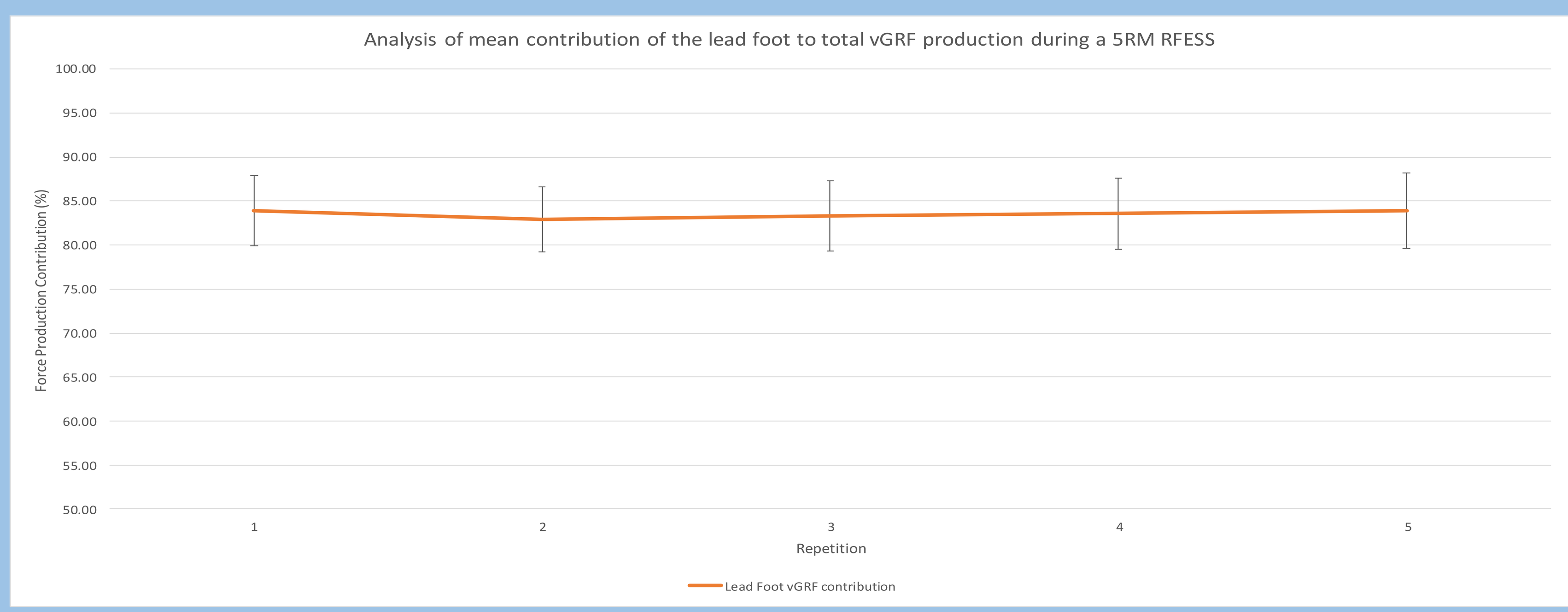
The rear foot elevated split squat (RFESS) is a multi-joint, unilateral resistance exercise, commonly used in strength and conditioning (McCurdy, 2017). McCurdy, Langford et al. (2004) and McCurdy and Langford (2005) have previously reported the RFESS as a reliable measure of unilateral leg strength (1RM ICC, 0.97- 0.99). The aim of this study was to firstly quantify the kinetic and kinematic characteristics of the RFESS 5RM test protocol. Secondly to profile the intra-set differences between repetitions.

**Methods**

26 volunteers were recruited, (age = 23.8 ±4.6 years, mass = 88.1 ±10.7kg, height = 1.79±0.1m), all subjects were engaged in a structured strength and conditioning program. Kinetic data was collected from the front and rear foot through two independent Kistler force plates.
Kinematic data was captured through Qualysis Track Manager System at 250Hz (Qualysis AB, Gothenburg, Sweden) using 10 cameras (six ceiling mounted and four, floor mounted).

Data was extracted and exported to Biomechanics Toolbar, and a Butterworth, fourth order filter applied. Subsequent data was further exported to R for analysis. A second data set was created in Biomechanics Toolbar, by time normalising the data to 101 time points.



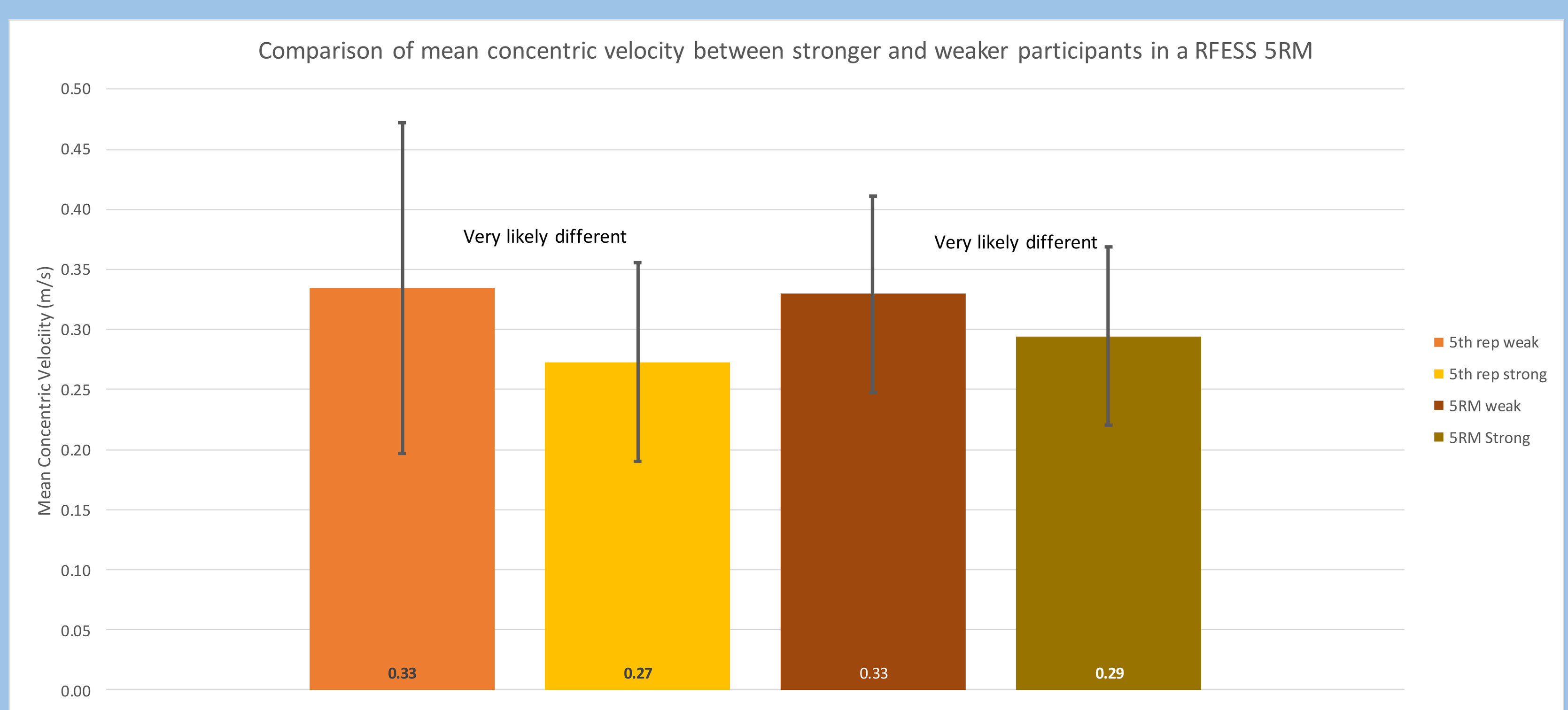



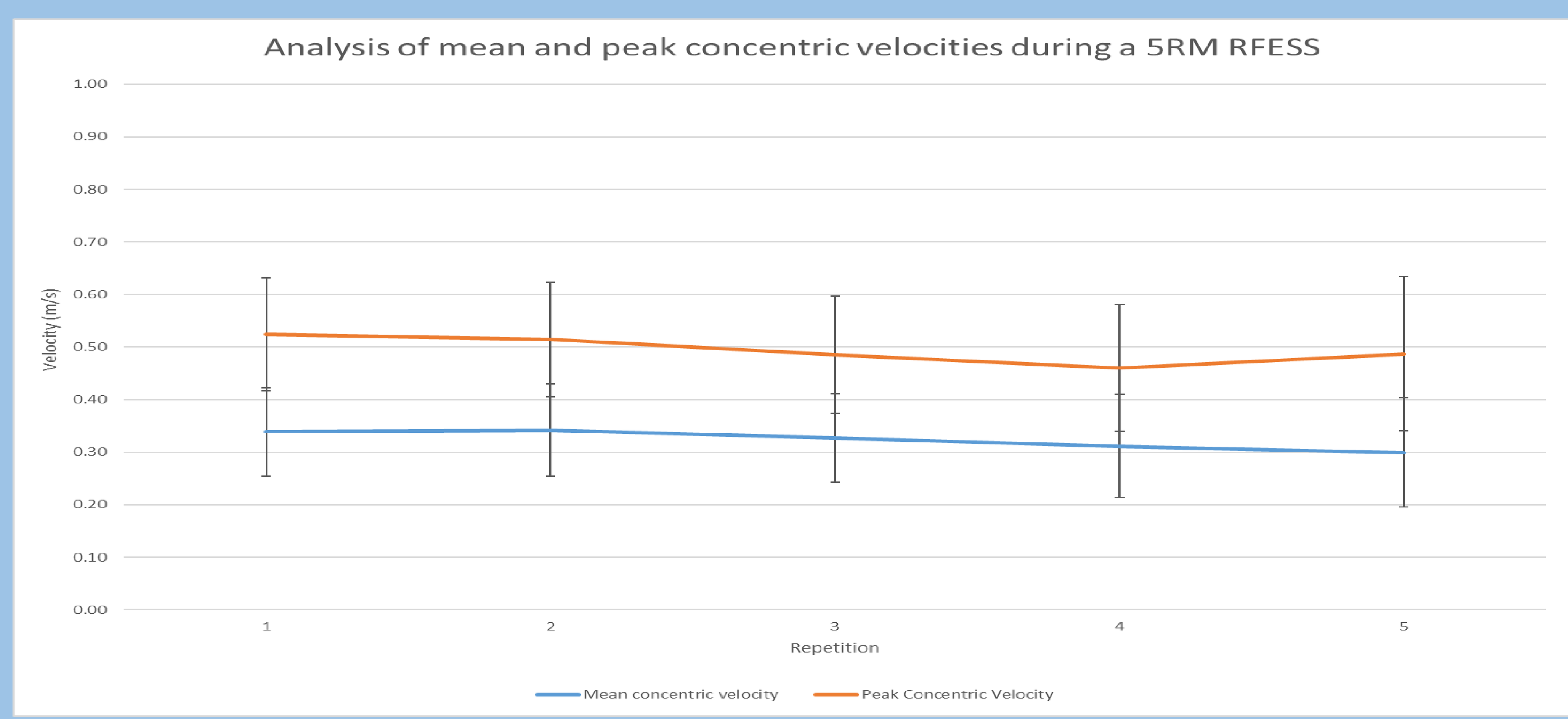

**RESULTS**

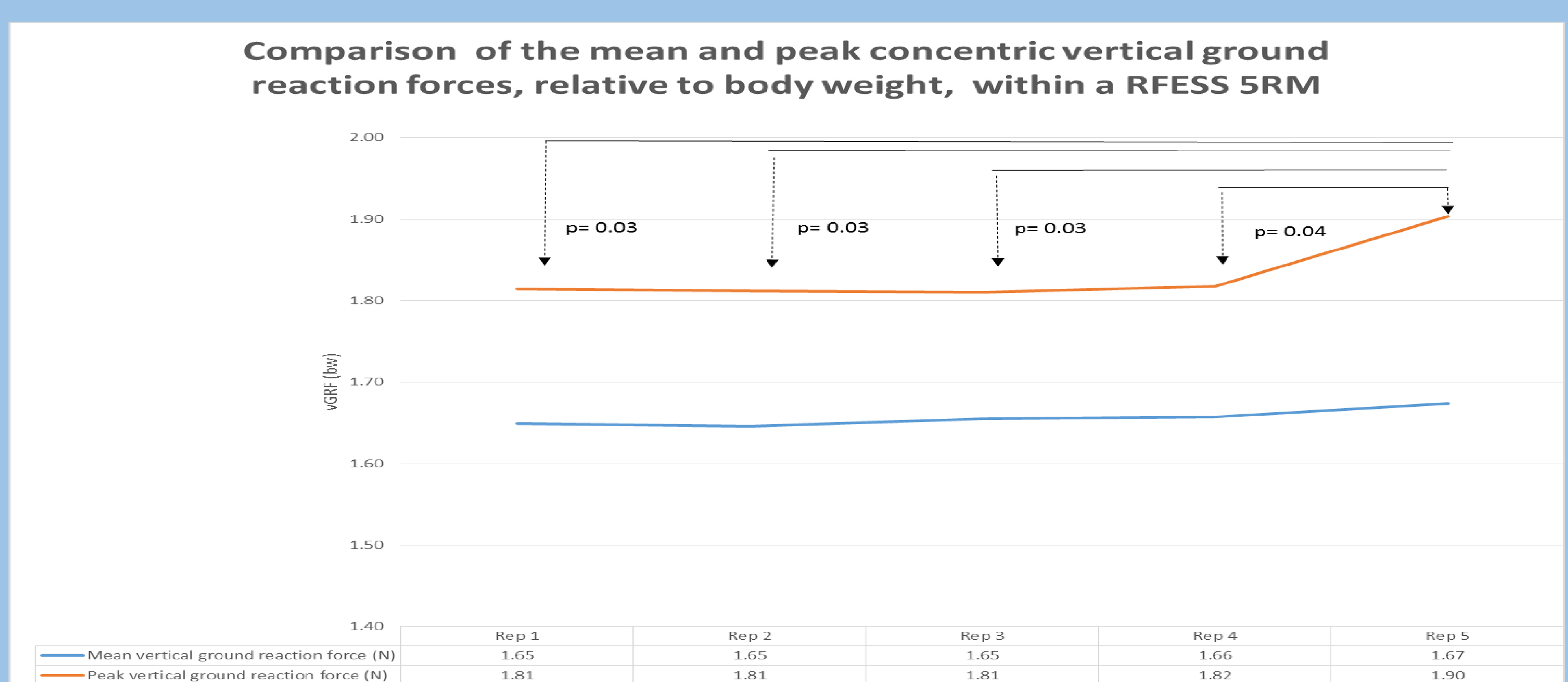
The mean load lifted was 84kg ±16.8kg (0.96 ±0.18 kg/kg). The mean vertical displacement of the bar was 0.38 ± 0.06m, mean concentric velocity was 0.32 ±0.05m/s and peak concentric velocity was 0.49 ±0.11m/s. The mean vertical ground reaction force (vGRF) of the lead foot was 1432.54±200.87N, (1.66 ±0.20BW). The lead foot produced 83.53±4.03% of total vGRF. There were unclear differences in all kinetic variables between all repetitions, except for peak (vGRF) of the lead foot only (1.90±0.28BW) of Repetition 5, which was very likely larger. Repetitions 1 and 2 were likely to very likely to have higher mean concentric velocities (MCV) than repetitions 4 and 5.

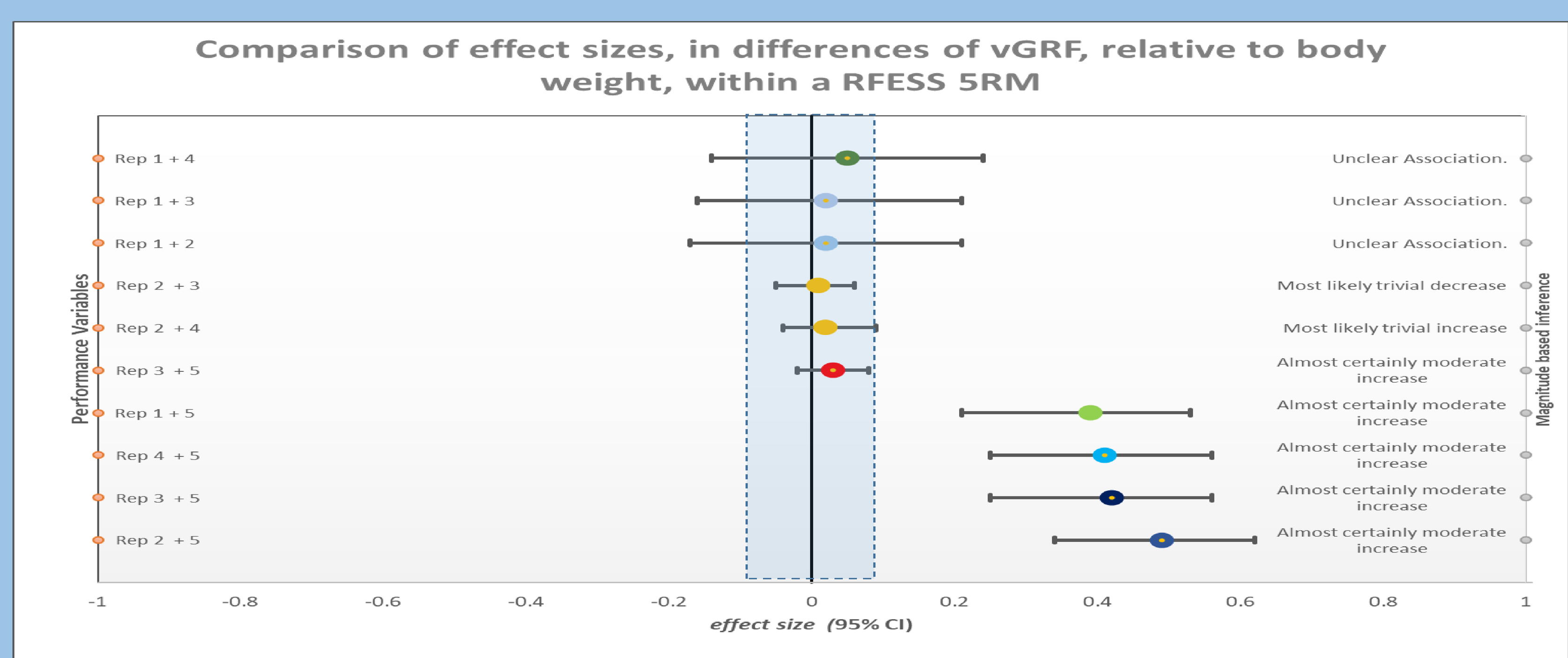
Stronger participants were able to achieve lower concentric velocities, both as a set mean and the 5th repetition of the set

Time normalisation to 101 time points of all repetitions found peak displacement occurred at point 51±6, where peak lead and rear foot vGRF occurred at points 56±33 and 60±40 respectively.




**Conclusion:**

The RFESS 5RM is valid and reliable method of measuring unilateral leg strength. Mean force contributions across the repetition of ≈15% with unreliable occurrences of peak rear foot vGRF, indicate a reliance on the lead for vertical displacement both eccentrically and concentrically. The RFESS can therefore be considered a unilateral exercise as no clear role of the rear foot could be defined.

A multi-repetition protocol can be used to determine maximal strength, yet intra-set differences may not exist prior to completion of the final repetition. It is recommended that the mean of the repetitions is taken when summarising the kinematic and kinetic variables in a multi repetition test. However, the final repetition MCV maybe used to determine relative intensity of the set or achievement of maximal performance. Based on the data from this study, this value may be 0.27m/s.

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# Variations in Strength Status Across the Menstrual Cycle in Eumenorrheic Women: A Systematic Review and Meta-Analysis

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## INTRODUCTION

Fluctuations in ovarian sex hormones (OSH) can explain variations in physical performance over the course of a menstrual cycle (Figure 1). Oestrogen peaks just prior to ovulation and is known to exert an excitatory effect on the nervous system, which has been hypothesised to increase strength compared to in the early-follicular and luteal phases (Lowe et al., 2010, *Exerc Sport Sci Rev*, 38:61-7). The effect that changes in OSH exert on strength-related tasks has received considerable attention, however the literature has not previously been reviewed and collectively analysed.

## AIM

The aim of this study was to systematically review and objectively analyse the current body of research that has investigated changes in strength-related variables during different phases of the menstrual cycle in eumenorrheic women.

## METHODS

The guidelines provided by the Cochrane Musculoskeletal Group (Ghogomu et al., 2014, *J Rheumatol*, 41:194-205) were used as the basis for this systematic review. Figure 2 provides a visual overview of the review and study selection process. A literature search was conducted in Pubmed, SPORTDiscus and Web of Science using search terms related to the menstrual cycle and strength-related measures. Studies were included if participants were eumenorrheic (21-35 days), at least one strength-related measure was taken, outcome measurements occurred in ≥2 phases, and a physiological measure was taken to identify or verify cycle phases. Studies were excluded if participants used oral contraceptives or hormone replacement therapy, and if comparative time points were separated by longer than one menstrual cycle. Two reviewers reached consensus that 21 studies met the criteria for inclusion. Methodological rigor was assessed using the National Heart, Lung, and Blood Institute Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies. Random effects meta-analyses were used to compare the early-follicular, ovulatory and mid-luteal phases for maximal voluntary contraction, isokinetic peak torque, and explosive strength.

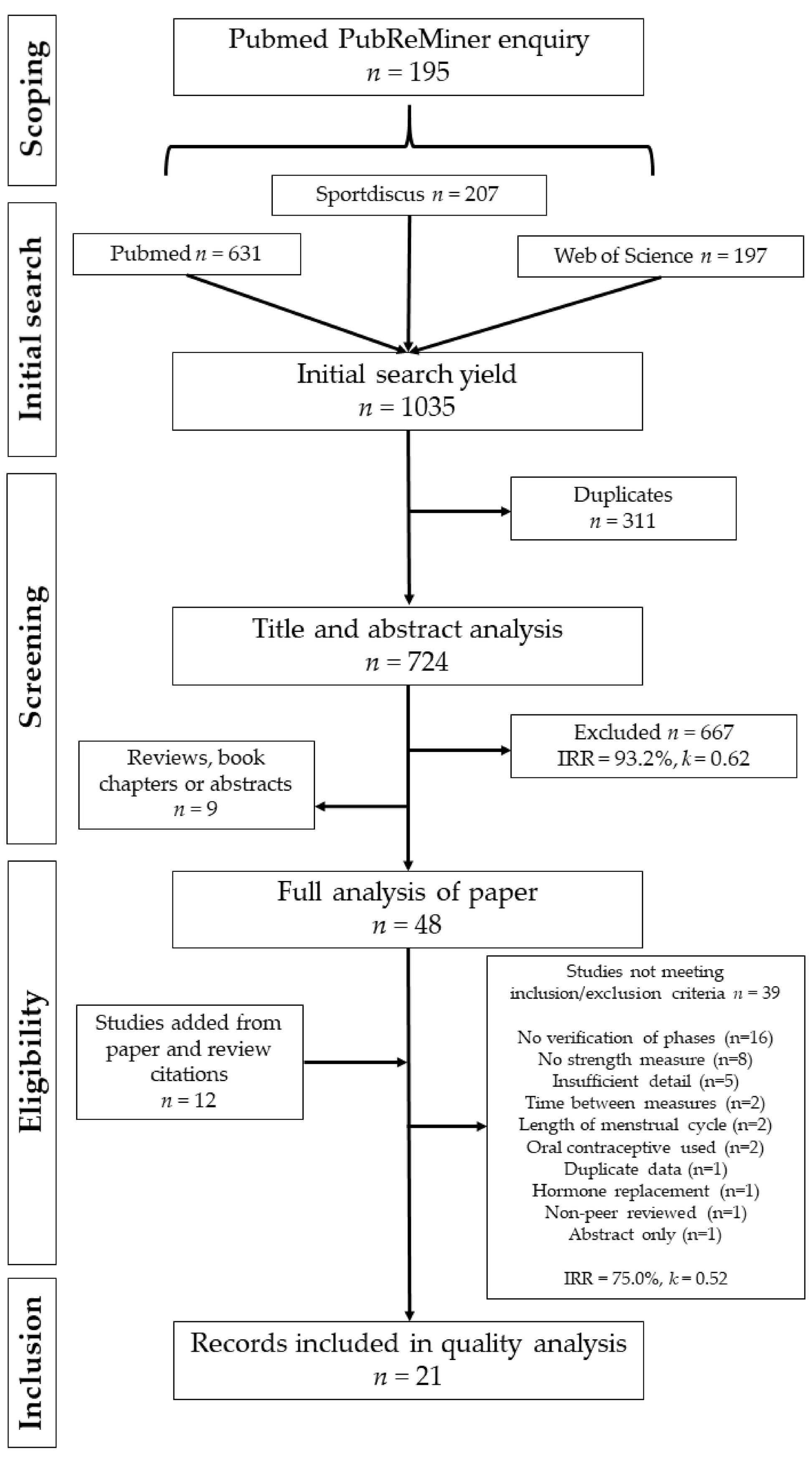


**Figure 2.** Search, screening and selection process for suitable studies. IRR = inter-rater reliability, *k* = Cohen's kappa statistic

## RESULTS

The assessment of study quality showed that a high level of bias exists in specific areas of study design (Figure 3). The Table shows that non-significant and trivial effect sizes ($p$≥0.25, Hedges $g$ <0.2) were identified for all strength-related variables in each comparison between phases. 95% confidence intervals for each comparison suggested the uncertainty associated with each estimate may extend to a small effect on strength performance (-0.43≤ $g$ ≤0.40). The heterogeneity for each comparison was also small ($p$>0.5, $I^2$<30%).

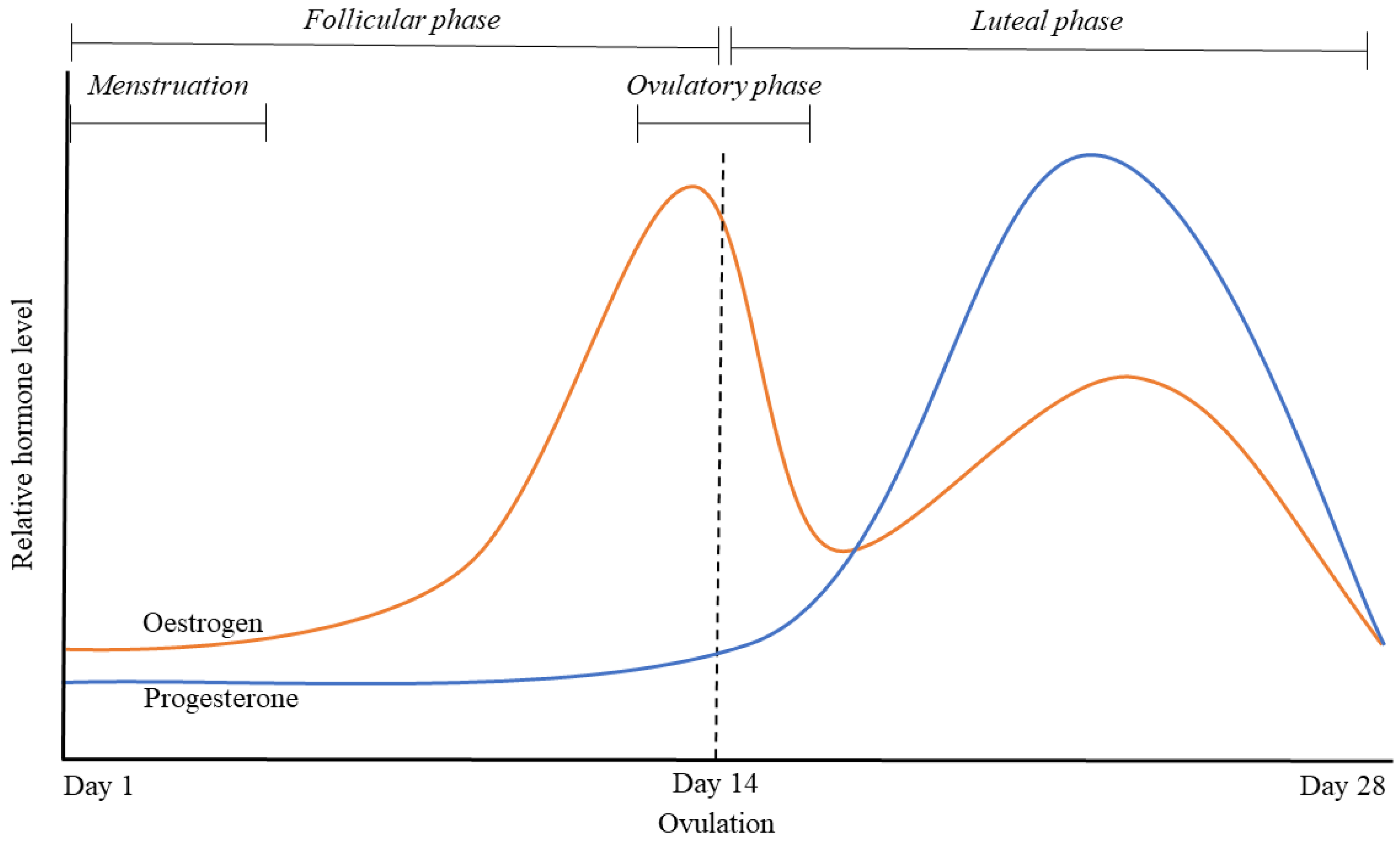


**Figure 1.** Fluctuating pattern of oestrogen and progesterone during the menstrual cycle and approximate duration of phases

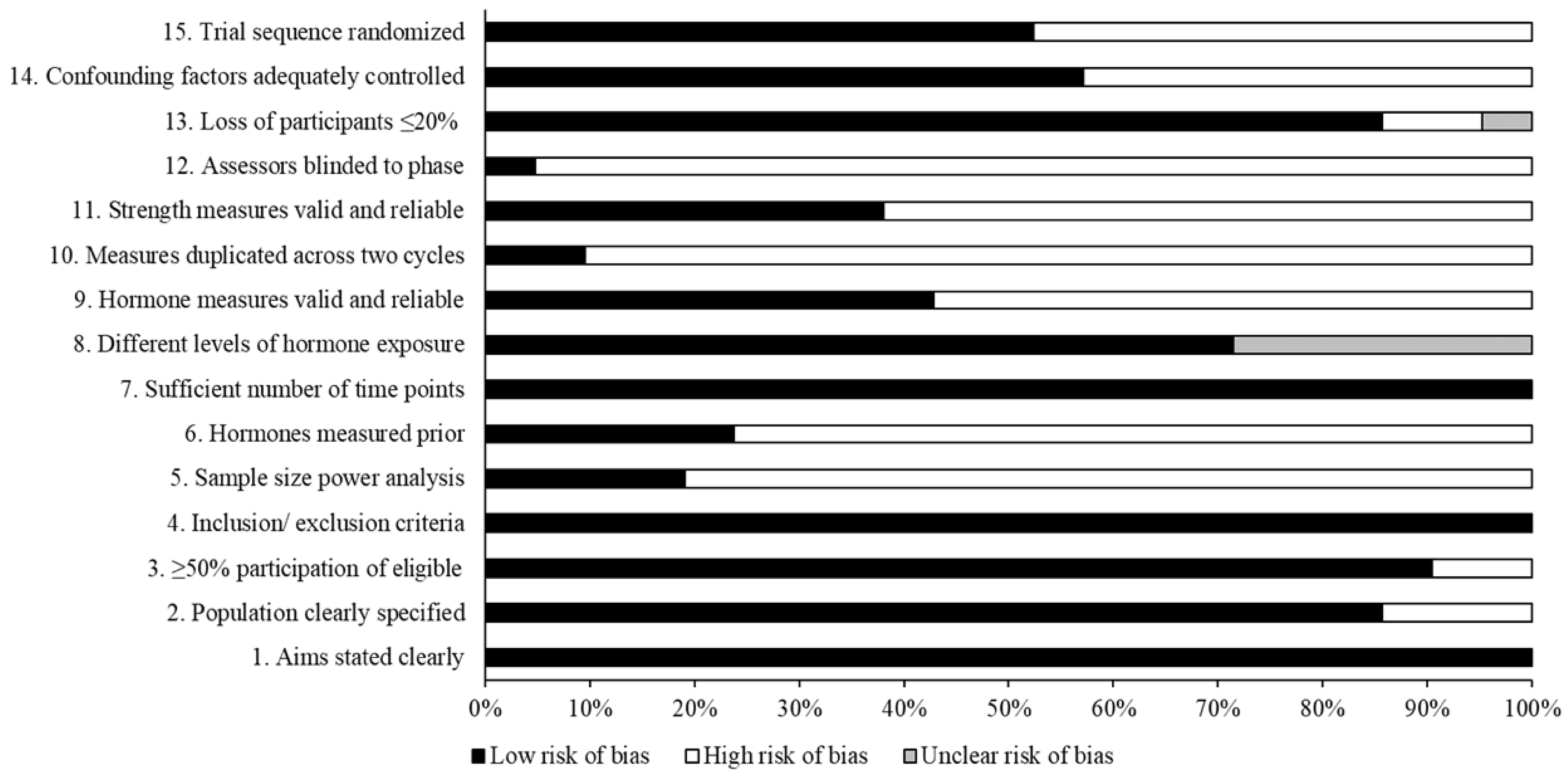


**Figure 3.** Summary of assessment of quality to highlight areas where a high risk of bias exists.

| Variables and sub-categories | Early-follicular *vs* ovulatory | | | Early-follicular *vs* mid-luteal | | | Ovulatory *vs* mid-luteal | | |
|---|---|---|---|---|---|---|---|---|---|
| | *n* | Hedges *g* (95% CI) | *p*-value | *n* | Hedges *g* (95% CI) | *p*-value | *n* | Hedges *g* (95% CI) | *p*-value |
| **MVC** | **98** | **0.04 (-0.24 to 0.32)** | **0.80** | **98** | **-0.01 (-0.29 to 0.27)** | **0.93** | **82** | **0.01 (-0.30 to 0.31)** | **0.97** |
| **Isok peak torque** | **85** | **-0.17 (-0.47 to 0.14)** | **0.28** | **139** | **0.03 (-0.21 to 0.26)** | **0.82** | **85** | **0.04 (-0.26 to 0.34)** | **0.78** |
| Knee extension | 56 | -0.06 (-0.43 to 0.31) | 0.76 | 83 | 0.03 (-0.27 to 0.34) | 0.84 | 48 | 0.09 (-0.31 to 0.49) | 0.66 |
| Knee flexion | 29 | -0.38 (-0.90 to 0.14) | 0.16 | 56 | 0.02 (-0.37 to 0.41) | 0.92 | 37 | -0.02 (-0.48 to 0.44) | 0.94 |
| **Explosive strength** | **79** | **0.09 (-0.22 to 0.40)** | **0.58** | **90** | **0.02 (-0.28 to 0.31)** | **0.91** | **56** | **-0.06 (-0.43 to 0.31)** | **0.76** |
| Jumping | 19 | -0.04 (-0.67 to 0.60) | 0.91 | 46 | -0.04 (-0.45 to 0.37) | 0.86 | 19 | -0.03 (-0.67 to 0.60) | 0.92 |
| Cycle erg PPO | 37 | 0.13 (-0.33 to 0.58) | 0.58 | 44 | 0.07 (-0.35 to 0.49) | 0.74 | 37 | -0.07 (-0.53 to 0.38) | 0.76 |
| RFD | 23 | 0.12 (-0.45 to 0.70) | 0.67 | - | - | - | - | - | - |

**Table**. Results of random effects meta-analysis on differences between strength-related measures in menstrual cycle phases. Early-follicular phase (≤7 days from menstruation onset), ovulatory phase (±2 days from ovulation), mid-luteal phase (21±2 days from menstruation onset or 7±2 days following ovulation). CI = confidence interval, MVC = maximum voluntary contraction, Isok = isokinetic, erg = ergometer, PPO = peak power output, RFD = rate of force development

## CONCLUSIONS

Strength status appears to be minimally affected by the fluctuations in OSH that occur during the menstrual cycle. This finding should be interpreted with caution due to the methodological shortcomings identified by the quality assessment. The main study design issues are associated with: accurate determination of phases, sample sizes, randomisation of trials, and blinding of assessors. Practitioners should be aware that individual differences may also exist, and that the adaptive response following strength training may be mediated by OSH, but this warrants further investigation.

**PROSPERO registration number: CRD42019126598.**

**Corresponding author: R.C.Blagrove@lboro.ac.uk**
**@rich_blagrove**

# Reactive strength fatigue in soccer players: reliability and practical applications

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## 1) Introduction

Repeated jumps (RJ) are a frequently prescribed training modality for athletic populations to improve fast stretch shortening cycle capabilities. Testing RJ could provide a simple and accessible assessment of fast stretch shortening cycle performance and fatigue. Despite the extensive use of RJ, there is limited research pertaining to the reliability and usefulness of RJ testing methods (Comyns et al., 2019). In addition, there is limited research into the nature of reactive strength fatigue in athletic populations.

## 2) Aim

Observe the fatigue response and determine reliability of a 30 second repeated jump test (30 RJT).

## 3) Experimental Design

**Participants**

n=19

Male semi pro soccer players

**Procedures**

10/5 Test (10/5 RJT) (Harper, 2011)
***Maximal RSI***

30 sec repeated jump test (30RJT)
***RSI Fatigue***

**Outcome Measures**

Jump Height (JH)

Contact Time (CT)

Reactive Strength Index (RSI)
RSI = JH/CT

Discrete 5 sec phases during 30 RJT

**Analysis**

One way RM ANOVA

% Change between 10/5 and 25-30s time phase

---

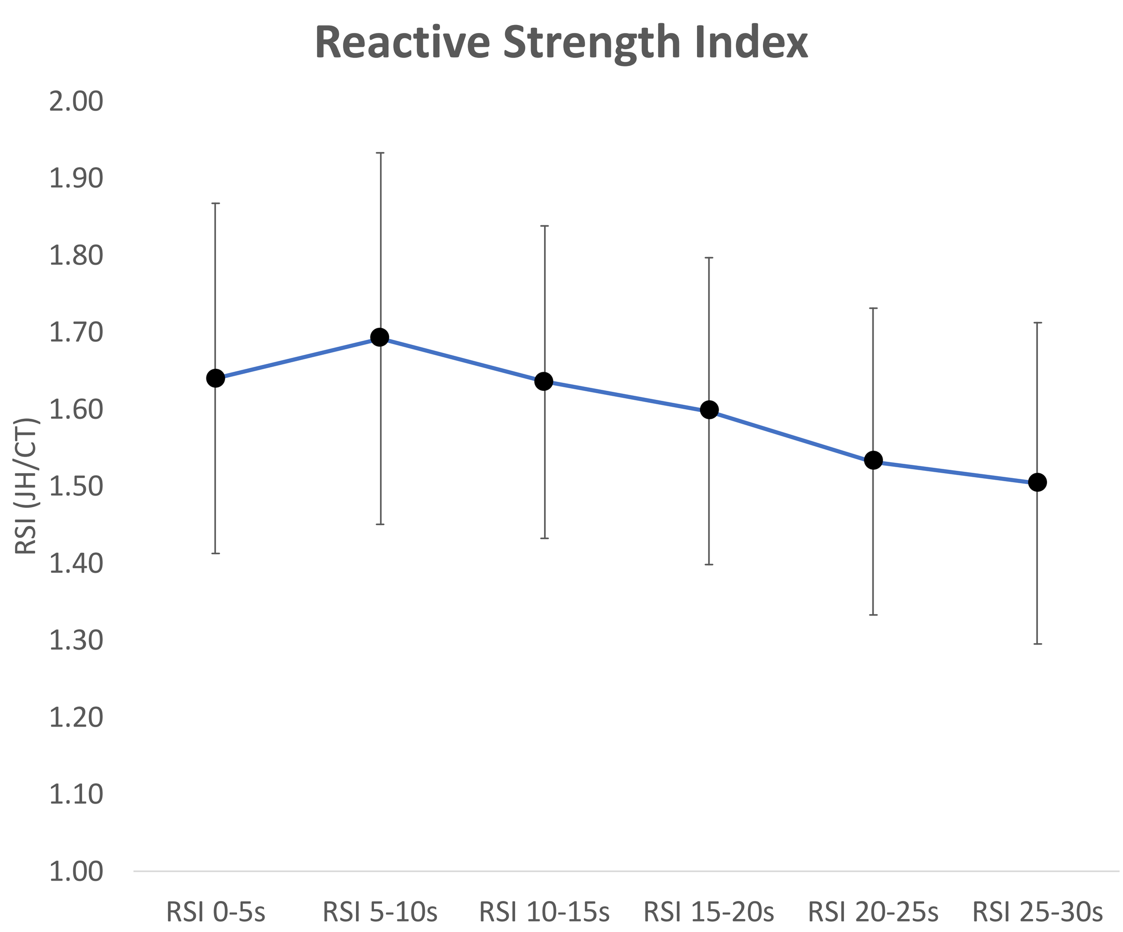
n=9

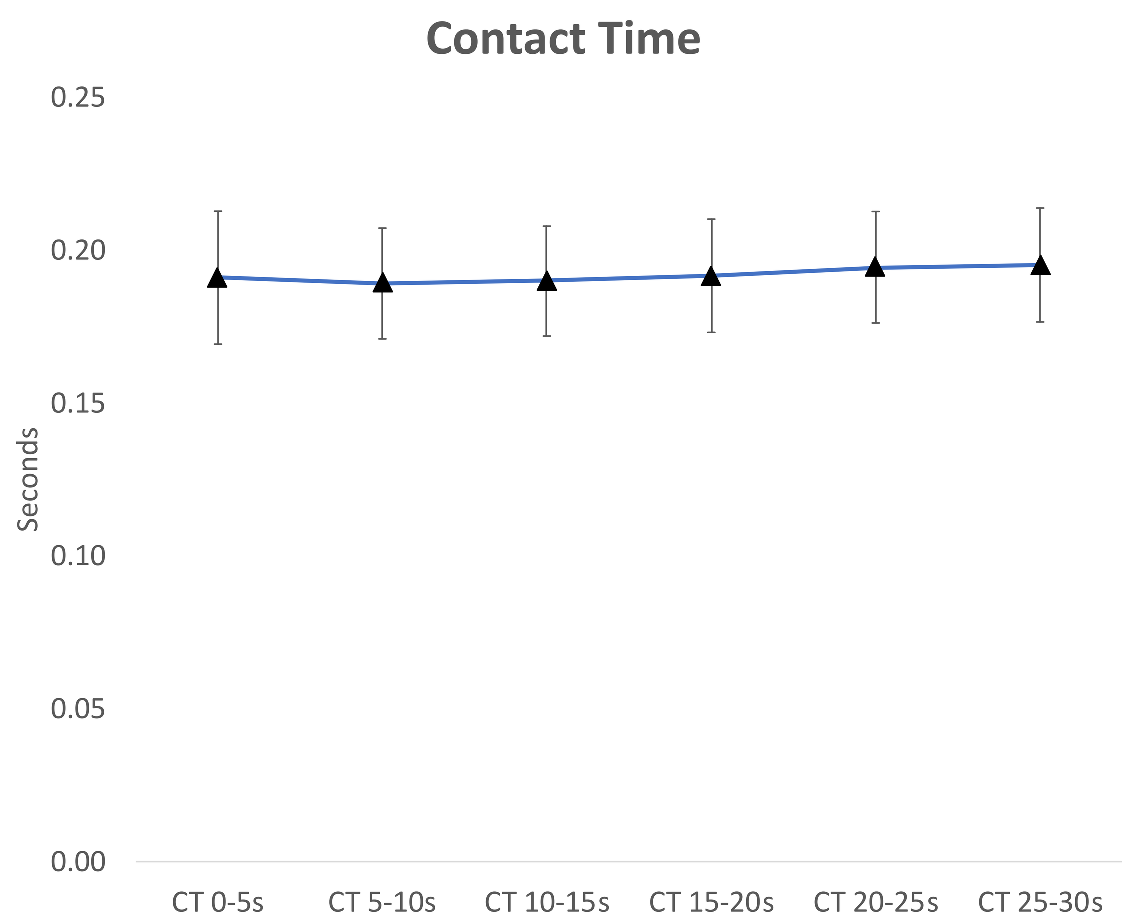
Male semi pro soccer players

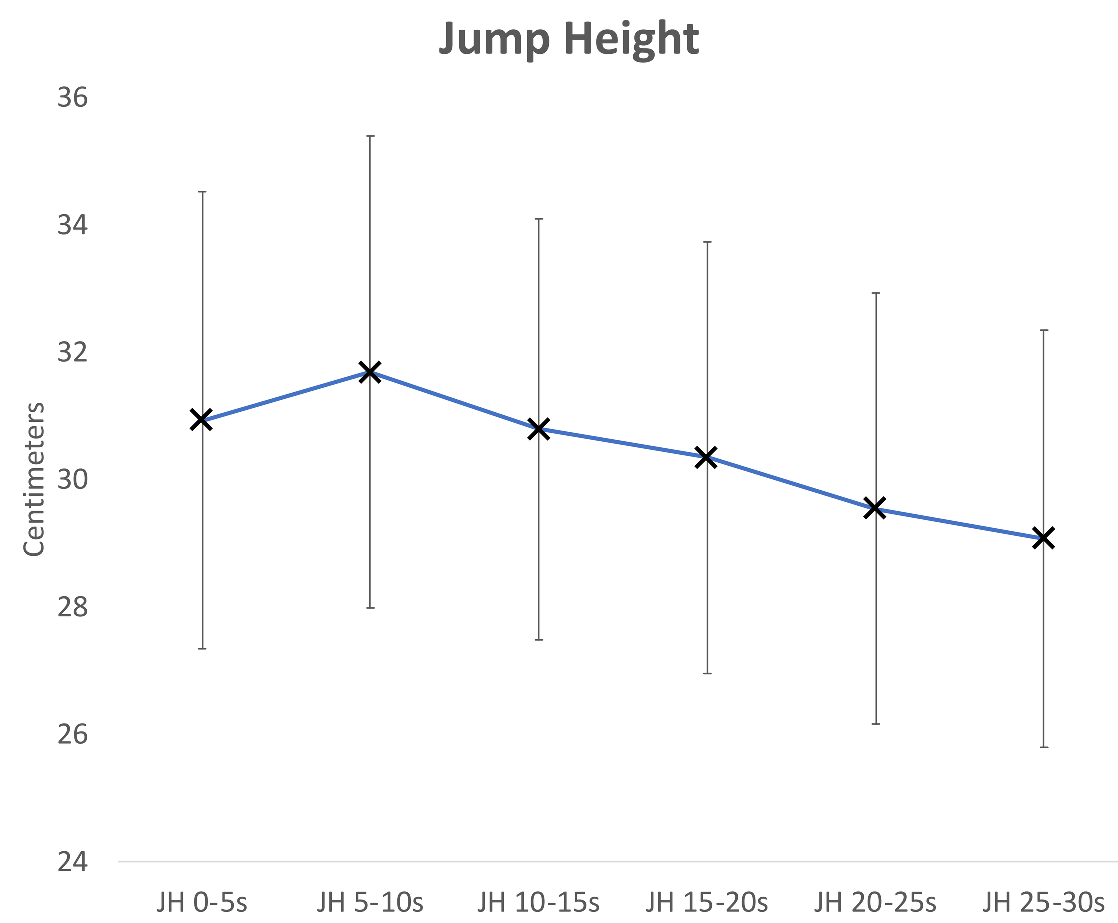
30RJT on two occasions (1 week apart)
***Reliability***

Intraclass correlation (ICC)
Correlation Coefficient (CV)

## 4) Results




In comparison to the 10/5 RJT, significant differences were detected across all RSI time phases ($p<0.01$). Similarly, JH differed significantly in five out of six time phases ($p<0.01$). CT differences were only detected in the final two time phases ($p<0.01$). In the final 5 second phase, RSI and JH decreased by 15.04% and 10.82% respectively, while CT increased by 4.92%.

| RSI | 0-5s | 5-10s | 10-15s | 15-20s | 20-25s | 25-30s |
|---|---|---|---|---|---|---|
| ICC | 0.87 | 0.86 | 0.86 | 0.83 | 0.86 | 0.89 |
| CV | 6.16 | 6.22 | 6.39 | 6.48 | 5.57 | 4.73 |

| CT | 0-5s | 5-10s | 10-15s | 15-20s | 20-25s | 25-30s |
|---|---|---|---|---|---|---|
| ICC | 0.86 | 0.9 | 0.89 | 0.91 | 0.9 | 0.9 |
| CV | 3.85 | 3.26 | 3.32 | 2.77 | 2.74 | 2.8 |

| JH | 0-5s | 5-10s | 10-15s | 15-20s | 20-25s | 25-30s |
|---|---|---|---|---|---|---|
| ICC | 0.82 | 0.71 | 0.74 | 0.72 | 0.83 | 0.75 |
| CV | 3.55 | 5.17 | 5.76 | 5.31 | 4.69 | 5.03 |

## 5) Conclusion

Changes in RSI were predominantly attributed to fluctuations in JH, while much smaller changes were observed in CT during the 30 RJT (43±2 repetitions). The 30 RJT exhibited strong inter-day reliability (CVs < 7% and ICCs > 0.8) for RSI, comparable to recent literature investigating the 10/5 RJT and a five maximal RJT in similar cohorts (Comyns et al, 2019). Therefore, the 30 RJT could provide an accessible and reliable method of assessing reactive strength fatigue in athletic populations.

**References**
Comyns et al. 2019. Int J Sports Phys Perf, pp.1-17.
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# Engage, Enthuse, Empower: Fostering Self-Sufficient Athletes

Sean J. Maloney

*Maloney Performance*

## BACKGROUND

Coach-athlete relationships are transient. Whilst some athletes may fly the nest for positive reasons (i.e. promotions or transfers), athletes must also be prepared for their nest to thrown out of the tree (i.e. deselection or loss of funding). Indeed, as coaches, we may too move on and find another nest to feather.

**Are we appropriately preparing athletes to fend for themselves? To cope with the uncertainty of not just sport, but life too?**

## THE 3 E's

**ENGAGE**

*To occupy or attract attention*

**ENTHUSE**

*To foster enjoyment and interest*

**EMPOWER**

*To give authority or power*

*To make someone stronger and more confident*

## THE 2 GOALS

1. **Help athletes understand the 'what' and 'why'**
2. **Help athletes make positive behavioural choices of their own free will**

## BENEFITS

Self-sufficient athletes, scholars of their sport and of the training process, should be best placed to…

- Determine strengths and weaknesses
- Gauge 'transfer'
- Monitor readiness and recovery

The better they can do the 80%, the better we can do the 20%

### Engage

- Find their 'why'
- Make the journey appealing
- Provide new challenges
- Promote cognitive involvement

### Enthuse

- Consider what elicits 'feel-good' response
- Goal attainment
- Self-efficacy
- Positive social interaction

### Empower

- Provide rationale and reasoning
- Promote autonomy from day one
- 'Periodise' programme self-government

## SUMMARY

**What happens when the coach-athlete relationship comes to an end? Hopefully, we've given the athlete everything they need to cope without us. Maybe they don't get another coach to follow us and they'll have to go it alone. And all athletes must face retirement at some point. Can we tell ourselves that we've done all we can to foster a self-sufficient athlete?**

## CONTACT

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SCAN ME WITH YOUR PHONE'S CAMERA

# Alternative Jump Variables as Surrogate Measures of Weightlifting Performance in National Weightlifters


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Xiang "Tyler" Yao [1]
Jake Harcoff [1]
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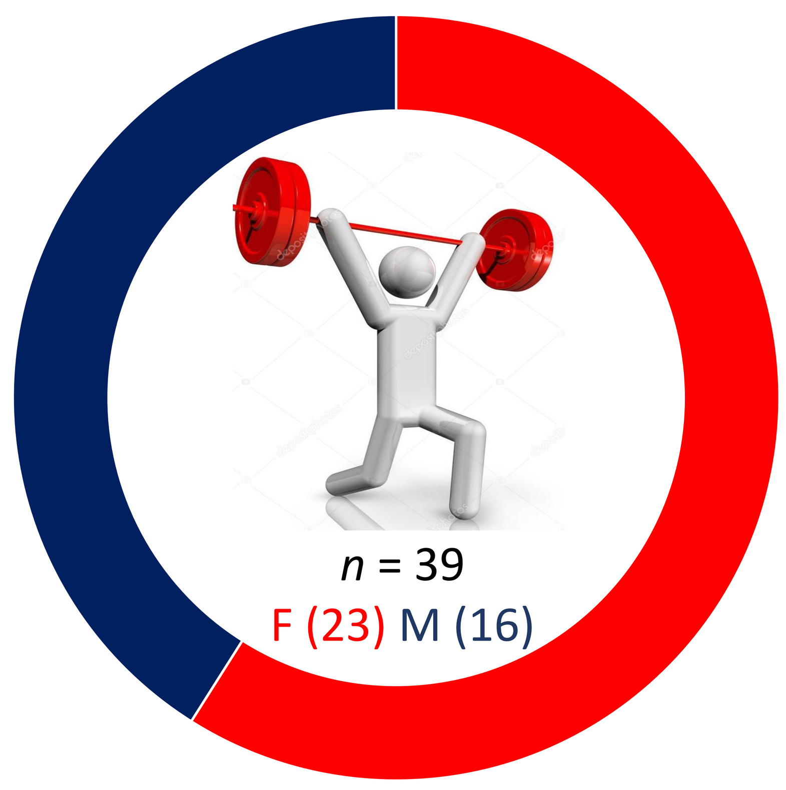
Anthony N Turner [1]


## Introduction

- Surrogate measures of weightlifting performance (WLp) have previously been monitored using loaded and unloaded squat jumps (SJ) (Bazyler et al 2018; Travis et al 2018; Carlock et al 2004) and countermovement jumps (CMJ) (Carlock et al 2004).
- Typically measures of jump height (JH) (Travis et al 2018; Carlock et al 2004) and peak power (PP) (Carlock et al 2004) and their associated scaled counterparts (Travis et al 2018; Carlock et al 2004) have been used to identify relationships between them and WLp.
- While these variables have been shown to have moderate to very strong relationships (r = 0.60-0.93) (Carlock et al 2004), further information into the underpinning mechanisms that contribute to such outcome measures has not yet been investigated and may provide insight into variables more sensitive to change, thus aiding the monitoring process.
- Also, given that the sport is divided into female and male categories, differences between variables by gender was also investigated.

## Methods




39 National Level Weightlifters participated in this project during the 2019 English Championships.
2 individuals did not achieve a total and were excluded from the respective analysis

**Experimental Design**

Athletes performed 2 CMJ's on a force plate (Kistler 9281BA, Winterhur, Switzerland) following their competition.

**Data Extrapolation**

Raw force-time data was analysed in a customised spreadsheet (Chavda et al 2018), with the variables outlined in table 1 extrapolated for analysis.

**Statistical Analyses**

CV and ICC with 95% CI was calculated for all variables. All data was non parametric and relationships were determined using a Spearmans rho with the alpha level set at 0.05.

| Variable |
|---|
| Snatch (Kg) |
| Clean & Jerk (Kg) |
| Total (Kg) |
| Jump Height (m) |
| RSI Mod |
| Peak Force (N) |
| Relative Peak Force (N/Kg) |
| Eccentric Impulse (N.s) |
| Concentric Impulse (N.s) |
| Concentric Impulse Duration (s) |
| Peak Power (W) |
| Relative Peak Power (W/Kg) |
| Concentric Average Power (W) |

## Results

### *Reliability*

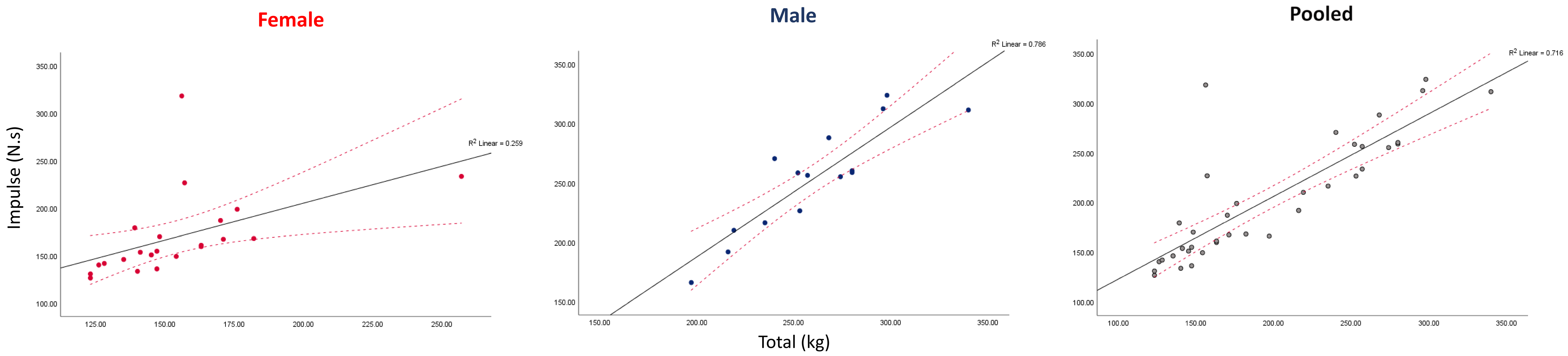
Concentric Impulse (N.s) was the most reliable variable (CV = 1.68%, ICC = 0.994, 95% CI: 0.989-0.997).

### *Differences*

Significantly more impulse ($t_{(37)}$ = -5.938, *p* = 0.000) was produced during the propulsive phase of the CMJ by males (Mean = 253.77, SD = 43.79 ) compared to females (Mean = 170.33 , SD = 42.72).

### *Relationships*

Concentric Impulse (N.s) was the highest correlating variable to snatch, C&J and Total achieved for females (*r* = 0.73, 0.73, 0.76, respectively), males (*r* = 0.78,0.83 and 0.85, respectively) and pooled (*r* = 0.85, 0.85 and 0.65, respectively).




## Conclusion & Practical Applications

- Concentric impulse from a CMJ has very strong relationships with WLp in both female and male weightlifters (*r* = 0.73-0.85, *p* <0.05).
- Concentric impulse may therefore be a good surrogate of WLp, potentially making it useful as a talent identification variable.
- Due to its low CV and high ICC, concentric impulse may also be a useful tool in the monitoring of weightlifting athletes.
- ✓ It is suggested that concentric impulse is used when analysing CMJ's on a force plate within the weightlifting population.
- ✓ Given there is a significant difference in female and male concentric impulse, it is suggested that decisions governed by athletic ability in potentially talented weightlifters should be analysed separately.

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BRITISH WEIGHT LIFTING

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# The effects of a 12-week neuromuscular training intervention on isometric mid-thigh pull kinetics and drop jump performance in trained young female

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## INTRODUCTION

- While some research has explored the effectiveness of neuromuscular training (NMT) programmes in young female gymnasts (2-4), these studies have primarily relied on performance outcomes during jumping protocols (e.g. jump height) without examining underlying mechanical adaptations (e.g. kinetic variables).
- Therefore, this study aimed to investigate the effects of a 12-week NMT intervention on isometric and dynamic force-time characteristics during an isometric mid-thigh pull (IMTP) and drop jump (DJ) respectively, in trained young female gymnasts.

## METHODS

- Thirty-three pre-pubertal female gymnasts were sub-divided into gymnastics + NMT (GYM+NMT; n = 17) or gymnastics only (GYM, n = 16) groups. The maturity characteristics were estimated using percent of predicted adult height attained; GYM+NMT = 76.1 ± 6.6 and GYM = 76.8 ± 6.5, respectively.
- The GYM+NMT group followed a 12-week NMT program consisting of two 1-hr sessions/week, while the GYM group did not receive the additional training stimulus. Data were collected for both the IMTP and 30 cm DJ protocols using dual force plates. The processed variables are presented in *table 1*.
- A 2 x 2 (group x time) repeated measures ANOVA with a Bonferroni post-hoc analysis was used to identify differences between groups, for all variables ($p < 0.05$), while effect sizes (Cohen's d) were calculated to interpret the magnitude of between-group differences (1).

## RESULTS

- Following the 12-week intervention, the GYM+NMT group produced significantly more absolute and relative peak force (*figure 1*), when compared to the GYM group ($p < 0.05$). For absolute and relative force at different time sampling intervals, the GYM+NMT group showed no significant changes.
- A similar pattern was observed for force at 50 milliseconds for the GYM group. However, the GYM group displayed a significant decrease in absolute and relative peak force at 90, 150, 200 and 250 milliseconds. Neither group showed significant improvements in jump height, stiffness, RSI or CoMFz correlation in the DJ protocol.

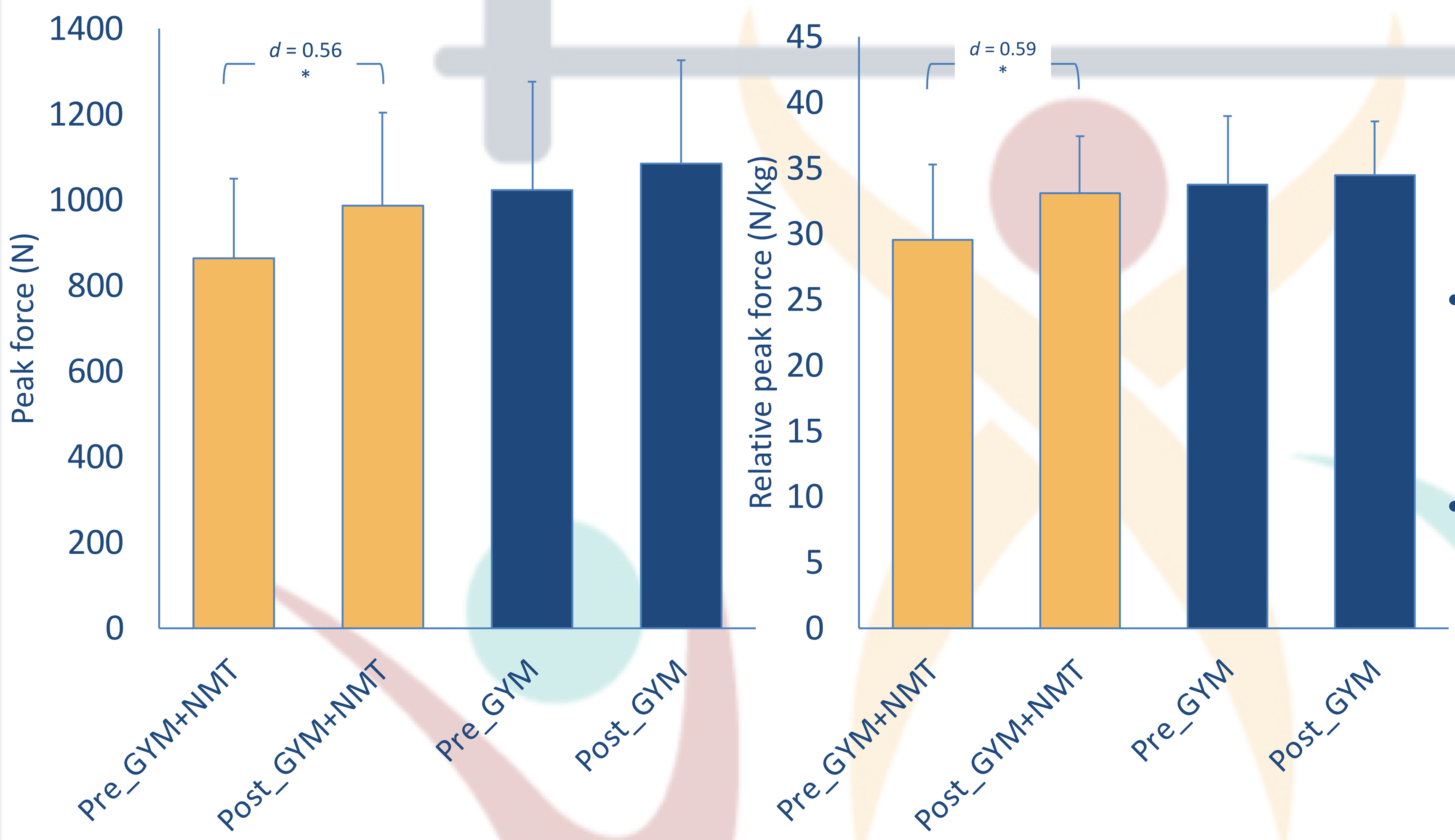


**Table 1.** Group analysis of IMTP kinetic variables and drop jump

| IMTP | Group | Pre | Post |
|---|---|---|---|
| Absolute force at 50ms (N) | Gym+NMT | 260.60 ± 83.48 | 276.34 ± 62.25$^{\#}$ |
| | Gym | 302.85 ± 86.98 | 294.94 ± 97.25 |
| Absolute force at 90ms (N) | Gym+NMT | 292.56 ± 94.11 | 291.74 ± 60.64 |
| | Gym | 343.40 ± 80.07 | 307.96 ± 99.85$^{\#}$ |
| Absolute force at 150ms (N) | Gym+NMT | 359.17 ± 118.60 | 337.77 ± 84.42$^{\#}$ |
| | Gym | 410.80 ± 103.45 | 349.73 ± 117.66$^{*\#}$ |
| Absolute force at 200ms (N) | Gym+NMT | 429.07 ± 160.60 | 399.62 ± 135.57$^{\#}$ |
| | Gym | 478.50 ± 151.78 | 402.47 ± 161.82$^{*\#}$ |
| Absolute force at 250ms (N) | Gym+NMT | 503.62 ± 206.98 | 495.26 ± 201.98 |
| | Gym | 566.48 ± 196.92 | 467.03 ± 209.33$^{\#}$ |
| Relative force at 50ms (N) | Gym+NMT | 8.73 ± 1.82 | 9.28 ± 1.15$^{\#}$ |
| | Gym | 10.00 ± 1.93 | 9.18 ± 1.71$^{\#}$ |
| Relative force at 90ms (N) | Gym+NMT | 9.84 ± 2.30 | 9.83 ± 1.20 |
| | Gym | 11.49 ± 2.29 | 9.59 ± 1.70$^{*\Psi}$ |
| Relative force at 150ms (N) | Gym+NMT | 12.09 ± 3.15 | 11.35 ± 1.86$^{\#}$ |
| | Gym | 13.88 ± 3.78 | 10.91 ± 2.38$^{*\Psi}$ |
| Relative force at 200ms (N) | Gym+NMT | 14.43 ± 4.59 | 13.39 ± 3.46$^{\#}$ |
| | Gym | 16.18 ± 5.43 | 12.57 ± 4.06$^{*\Psi}$ |
| Relative force at 250ms (N) | Gym+NMT | 16.82 ± 5.79 | 16.67 ± 5.64 |
| | Gym | 19.25 ± 7.14 | 14.62 ± 5.76$^{*\Psi}$ |
| **Drop jump** | **Group** | **Pre** | **Post** |
| GTC (ms) | Gym+NMT | 200.59 ± 64.16 | 193.12 ± 39.00 |
| | Gym | 203.44 ± 59.68 | 187.47 ± 31.56 |
| Jump height (cm) | Gym+NMT | 15.63 ± 4.16 | 17.34 ± 3.95$^{\#}$ |
| | Gym | 18.37 ± 3.89 | 17.99 ± 3.54 |
| RSI | Gym+NMT | 0.83 ± 0.27 | 0.94 ± 0.32$^{\#}$ |
| | Gym | 0.95 ± 0.25 | 0.99 ± 0.26 |
| Stiffness (kN/m) | Gym+NMT | 17.42 ± 8.46 | 16.41 ± 8.32 |
| | Gym | 19.46 ± 11.31 | 17.56 ± 6.33 |
| CoMFz correlation | Gym+NMT | -0.91 ± 0.06 | -0.94 ± 0.04 |
| | Gym | -0.89 ± 0.10 | -0.92 ± 0.05 |

$^{*}$= sig. less than the pre-testing;
$^{\#}$ = Small effect size (0.20-0.59); $^{\Psi}$= Moderate effect size (0.60-1.19)

## PRACTICAL APPLICATIONS AND CONCLUSIONS

- The 12-week intervention significantly improved the maximal force producing capabilities of young female gymnasts, beyond gymnastics training alone. However, neither group significantly improved measures of jump height, stiffness, RSI or CoMFz correlations, which indicates that the NMT program did not elicit a superior training stimulus in fast stretch-shortening cycle function to their habitual gymnastics training.
- The NMT program primarily targeted the development of movement competency and basic strength, therefore, it is likely that the GYM+NMT group experienced specific adaptations to the imposed demands.
- Experienced, technically competent young female gymnasts may require NMT programs with higher intensities and longer durations to elicit further improvements isometric and dynamic force-time characteristics.

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Youth Physical Development Centre

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# Effects of six-weeks change of direction speed and technique modification training on cutting performance and movement quality in male youth soccer players

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## 1. Introduction

- Cutting manoeuvres are important actions associated with soccer performance (1) and a key action associated with non-contact anterior cruciate ligament injury (2); thus, training interventions that can improve cutting performance and movement quality is of great interest to practitioners.
- Change of direction (COD) speed training has been shown to improve COD performance (3), while reductions in knee joint loads have been observed following COD technique modification training (4). However, there is a paucity of research considering the implications of COD speed and technique modification training on both performance and injury risk, particularly in soccer players.

## 2. Aim

To determine the effects of a six-week COD speed and technique modification training intervention on cutting performance and movement quality in male youth soccer players (U17s, n=8), in comparison to a control group (U18s, n=11) who continued normal training.

## 3. Methods

- A non-randomized controlled 6-week intervention study with a pre-to-post design was used.
- Intervention group (IG) (U17s) performed two COD speed and technique modification training sessions per week (20 mins) for 6 weeks (Figure 1), with external verbal coaching cues (Figure 2). Soccer players from the same club (U18s) acted as the control group (CG) and continued their normal field-based warm-ups (low-level jump-landing and sprint drills).
- 70° cutting performance (5-m entry and exit) was assessed based on completion time and COD deficit (CODD), and the field-based cutting movement assessment score (CMAS) qualitative screening tool was used to assess cutting movement quality using three Panasonic Lumix Fz-200 cameras (100Hz).
- The CMAS is based on mechanical determinants of peak knee abduction moments (lateral trunk flexion, extended knee posture, knee valgus, hip and foot internal rotation) and has been validated against 3D motion analysis (5).

**Weeks 1-2**
Technique Acquisition
Teaching deceleration and cutting technique
Pre-planned/low intensity

→

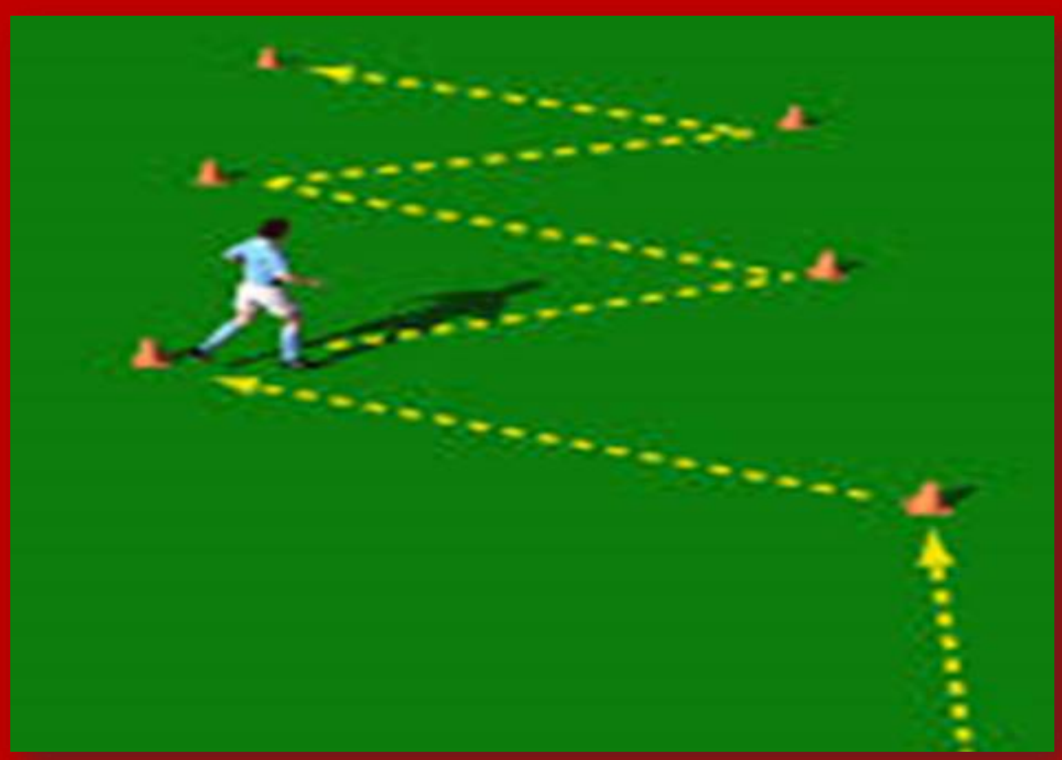
**Weeks 3-4**
Technique Retention and Integrity
Drills performed maximally
under high mechanical loading

→

**Weeks 5-6**
Movement Solutions
Unanticipated drills
Sports-specific drills

**Figure 1.** Cutting development framework training intervention

## Six-weeks COD speed and technique modification training improves cutting performance and movement quality in male youth soccer players



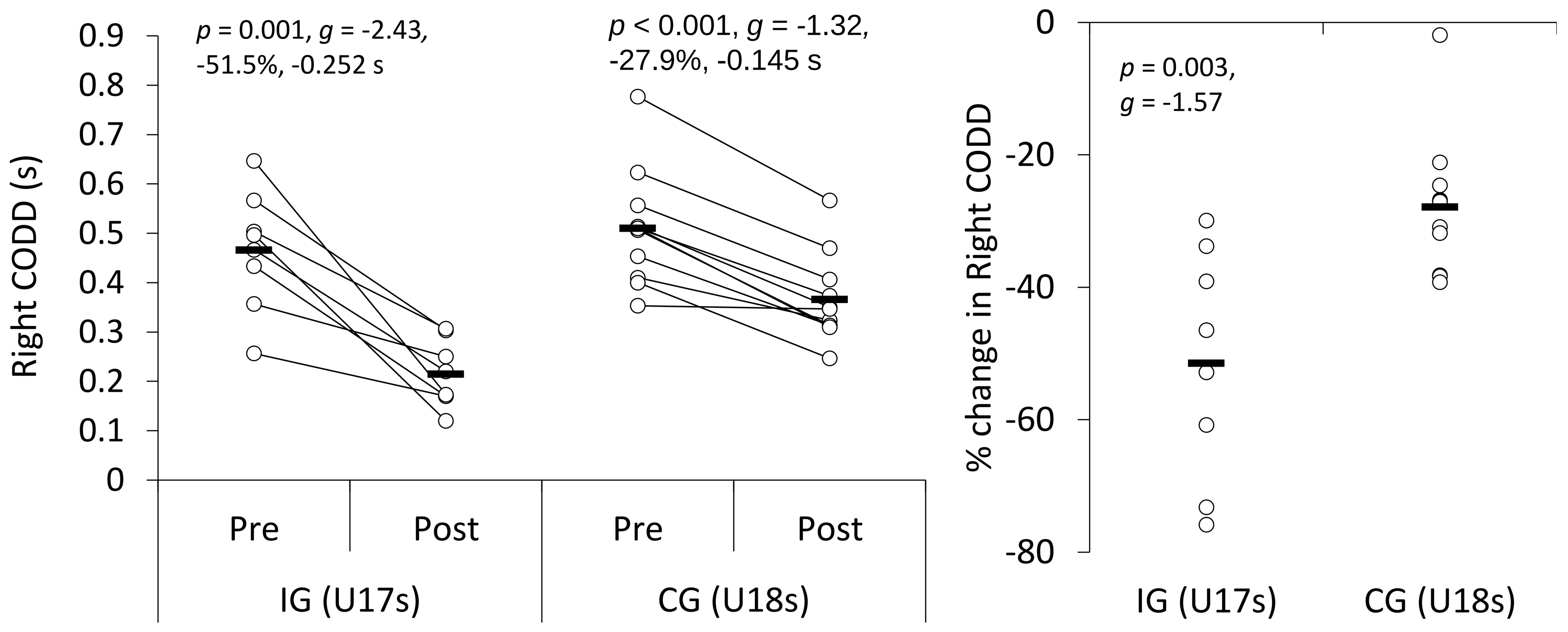
| Coaching cue | | Purpose |
|---|---|---|
| "Push the ground away" | → | Promote ML force propulsion, COD angle, and subsequent exit velocity |
| "Lean towards the goal" | → | Promote optimal alignment of the trunk and whole-body over the stance phase |
| "Slam on the brakes" | → | Promote effective braking during penultimate step(s) to reduce momentum prior to cut |

**Figure 2.** Cutting development external verbal coaching cues

## This form of training can be easily integrated into the warm-ups of soccer field-based sessions

## 4. Results

- Two-way mixed ANOVAs (group; time) revealed significant main effects for time ($p \leq 0.041$, $\eta^2 = 0.224$-$0.839$) (pre-to-post changes) and significant interaction effects ($p \leq 0.025$, $\eta^2 = 0.262$-$0.330$) of time and group for cutting completion times, CODDs, and CMASs (Figure 3).
- Improvements in completion time ($p < 0.001$, $g = 1.90$, -11.7% vs. $p < 0.001$, $g = -1.21$, -5.9%) and CODD ($p \leq 0.012$, $g = -2.43$, -51.5% vs. $p < 0.001$, $g = -1.32$, -27.9%) for the IG were approximately two times greater than the CG and significantly different ($p \leq 0.025$, $g = -1.09$ to $-1.57$) (Figure 3).
- Lower CMASs (i.e. improved cutting movement quality) were observed only in the IG ($p = 0.025$, $g = -0.85$, -22.5%, -1.46 score) compared to the CG ($p = 0.779$, $g = 0.08$, +5.6%, +0.12 score) (Figure 3).



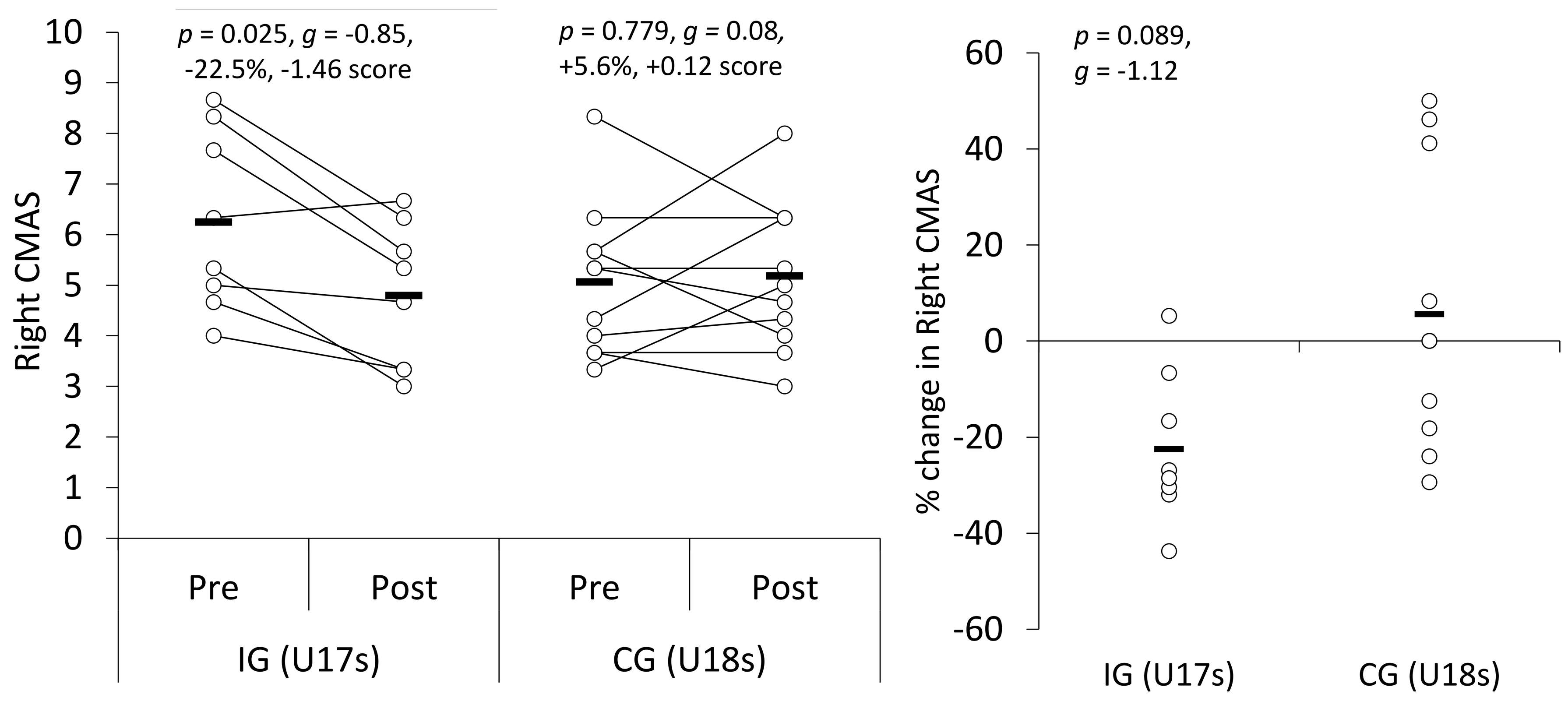




**Figure 3.** Pre-to-post changes in CMAS and CODD

## 5. Conclusion and Practical Applications

COD speed and technique modification training, in addition to normal skills and resistance training, improves cutting performance and movement quality in male youth soccer players. Practitioners working with male youth soccer players should implement COD speed and technique modification training to improve cutting performance and movement quality, which may decrease potential injury-risk.

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# The Effect of an 8 Week Resistance Training Program on Competitive Youth Swimmers


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## Introduction

Research has outlined the importance of muscular strength and the ability to generate force by the arms and legs in swimming performance. A clear correlation has been identified between swimming race times and athlete performance in strength and speed testing (Toussaint & Hollander, 1994**)**. Dry-land resistance training is becoming common place in competitive swimming, however, to-date very little research has evaluated the impact of resistance training programs on youth athletes (Trappe & Pearson, 2012). As the principles of youth strength training become increasingly understood the number of technical coaches and athletes looking for guidance is growing. Competitive swimmers train 12-18 hours per week in the pool (Mujika *et al*., 1995), therefore athletes under the age of 18 often struggle to find time for specific strength and conditioning sessions due to the addition of other time commitments (school/homework, employment, social). Therefore, the aim of this study was to assess the influence of a single session per week 8 week training program on the physical qualities of competitive youth swimmers.

## Methods

- 19 youth swimmers (male = 12 and female = 7), training a minimum of 12 hours per week (13.2±1.9 hours training) were recruited for this study ((Mean **±** *SD*) age: 14.4 ± 2.7 years; stature: 163 ± 11 cm; body mass: 60.5 ± 10.1 kg; performance level: club - international).
- Participants followed an 8 week training intervention with testing in weeks 1 and 10 (1 session x week). The resistance training program was split up into phases focussing on muscle contraction types as outlined in Figure 1.
- Participants completed assessments including stature and maturation (Khamis-Roche, 1994), squat jump (cm), countermovement jump (cm), 10-5 jump test/reactive strength index (RSI) (m.s$^{-1}$), maximum press ups (*n*) and maximum isometric pull up (s).
- Paired samples t-tests ($P < 0.05$) were carried out on all dependent variables, with Cohen's *D* effect sizes calculated to measure the strength of the difference (0.2 = small, 0.6 = moderate, 1.2 = large and 2.0 = very large). Pearson correlation coefficient (*r*) was calculated to assess the relationship between maturation and the performance parameters.

### The Training Program

Key movement patterns were maintained through the 8-week training phase, with coaching cues directing athletes toward rapid concentric movement.


Figure 1. Outline of 8 week S&C training program.

## Practical Applications

- Strength and Conditioning coaches should look to employ specific strength training programmes for youth swimmers in order to improve lower body explosiveness and upper body pulling strength.
- The above programme could be used as a template, in which specific phases focusing on eccentric, isometric and concentric muscle actions might help athletes with low training ages learn and develop.
- Practitioners should ensure the training time spent in the gym is complimentary to other methods of training, with confidence that a single session a week could help develop swimmers physically, having a positive effect on performance.

## Results

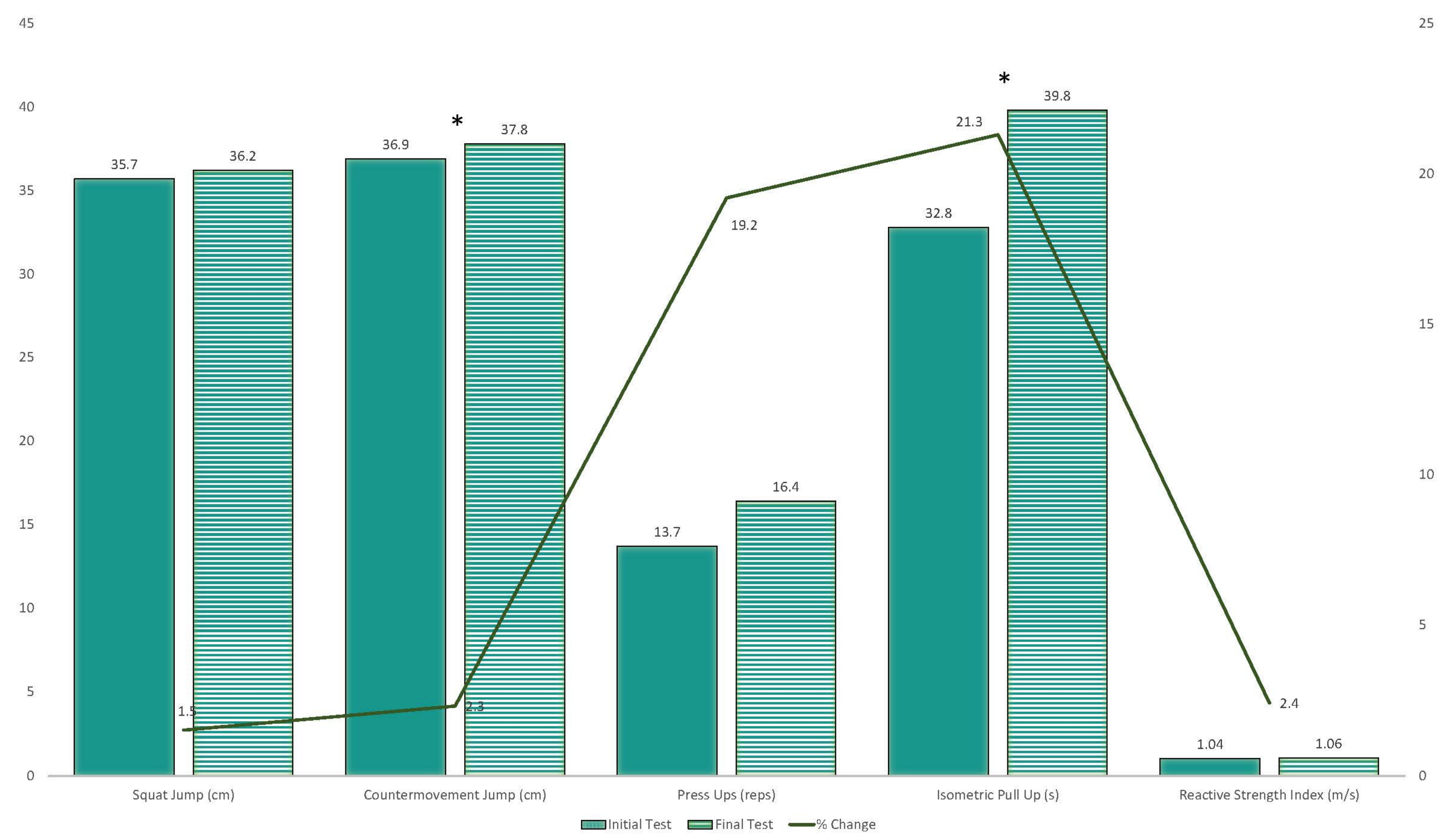


Figure 2. Test-retest data for performance assessments. * indicates significant difference ($P < 0.05$)

After 8 weeks of training, participants experienced a significant improvement in countermovement jump (t(18) = -3.99, $P = 0.001$, $d = 0.2$) and maximum isometric pull up time (t(18) = -2.31, $P = 0.03$, $d = 0.22$).

- Squat jump, maximum press ups and RSI did not significantly improve over the 8 week intervention.
- Pearson's correlation coefficients demonstrated a moderate to strong relationship between maturation and maximum press ups ($r = 0.55$). All other dependent variables showed a weak correlation with maturation.
- The average maturation status of the participants 95 ± 4.7% (current % of adult height), had an influence on other aspects of the physical testing, however, was not statistically significant.

## Conclusions

- An eight week programme with specific muscle action focus is an effective method of improving CMJ and maximal pulling strength in young swimmers
- Administering one training session a week is appropriate in developing physical capacities in youth swimmers.
- Small effect sizes, however, may indicate that the study was underpowered and therefore these findings should be taken with caution..

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# THE RELIABILITY OF LOAD-VELOCITY PROFILING IN THE POWER CLEAN

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## 1. Introduction

- A Load-velocity profile (LVP) can be used to assess strength capabilities in athletes and can provide an added level of accuracy when prescribing load.
- Strong inverse linear relationships and high levels of within-participant reliability have been observed in a number of strength exercises (1-4).
- Conversely, large between-participant variability has been detected at specific relative loads, indicating that an individualised LVP may be a more appropriate method to use (1-2).
- Understanding the effectiveness of this approach is still in its infancy, with insufficient data investigating Olympic weightlifting exercises such as the power clean.
- Therefore, the purpose of this research is to investigate the load-velocity relationship in the power clean, comparing pooled vs. individualised LVPs.
- The secondary purpose is to assess the reliability of this relationship across a number of relative loads.

## 2. Methods

- Ten competitive weightlifters (8 male, 2 female) (mean ± SD; age: 25.0 ± 5.6 y; body mass: 73.6 ± 13.9 kg; stature: 169.6 ± 6.6 cm) completed baseline one-repetition maximum (1RM) assessments in the power clean (1RM: 103.0 ± 22.8 kg; kg/body mass: 1.4 ± 0.2).
- Three LVPs consisting of incremental protocols (40-100% 1RM) were completed, each separated by a minimum of 48 hours.
- Mean (MV) and peak (PV) barbell velocity was recorded using a linear-position transducer (Gymaware).
- The load-velocity relationship was determined using linear regression (*r*) and standard error of estimate (SEE) in pooled and individualised LVPs. Coefficient of Variation (CV) assessed between-participant variation at each relative load.
- Intraclass correlation coefficient (ICC), technical error of measurement (TE) and CV assessed within-participant reliability at relative loads.
- High reliability was defined a priori as: ICC > 0.7; CV < 10% (3).

## 3. Results

**Table 1.** Linear regression and second-order polynomials (*r*) for the back squat and power clean. Pooled vs. pooled individualised vs. individualised data. *MV* Mean Velocity; *PV* Peak Velocity.

| | | Linear Regression (*r*) | | |
|---|---|---|---|---|
| | | Pooled | Pooled Individualised | Individualised |
| Power Clean | MV | 0.87 | 0.97-0.99 | 0.87-0.99 |
| | PV | 0.81 | 0.96-0.99 | 0.85-0.99 |

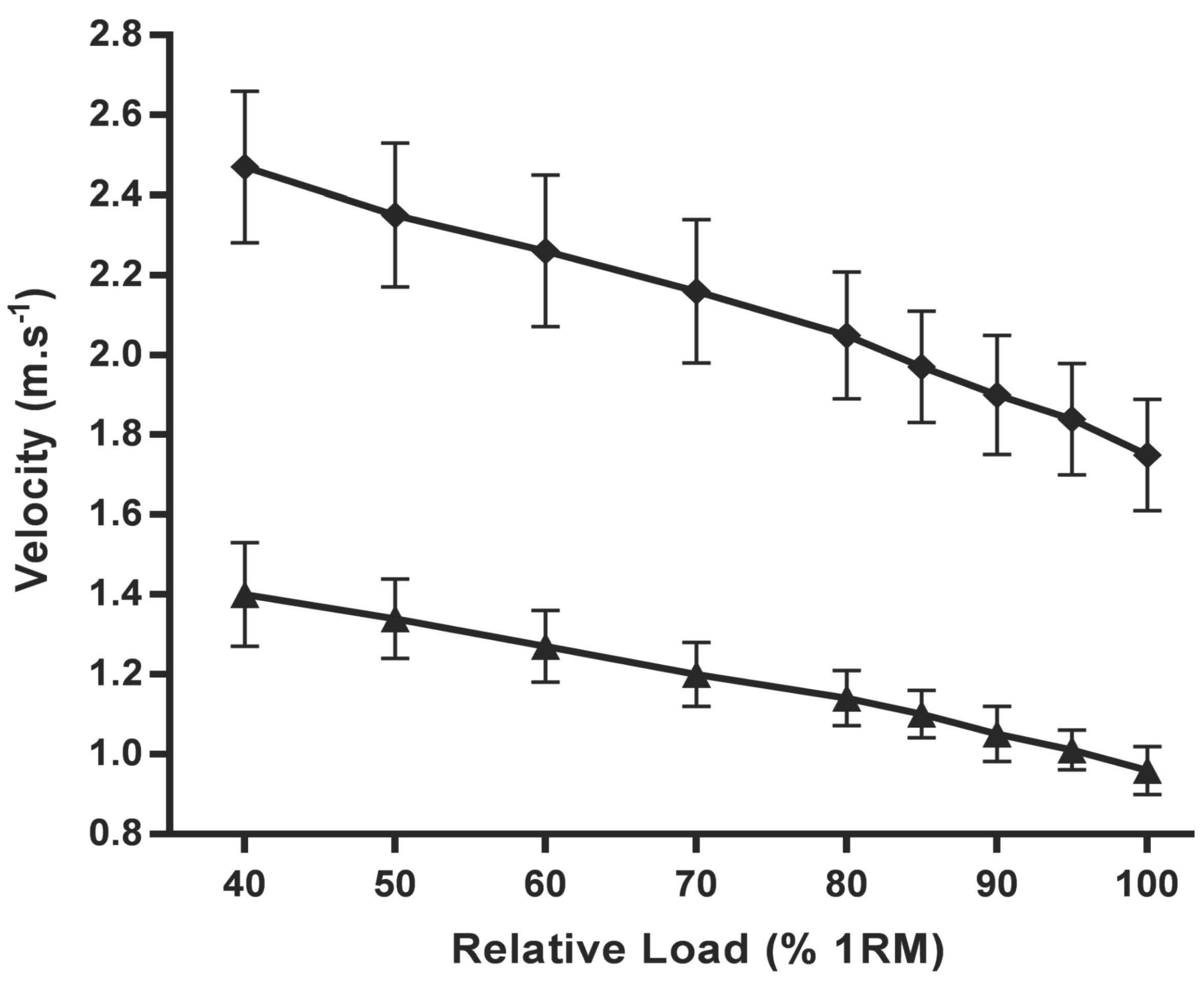


**Figure 1.** Group mean (SD) values from three load-velocity profiles for mean velocity (m.s-1) (▲) and peak velocity (m.s-1) (◆) for power clean. *1RM* one repetition maximum.

- Strong inverse linear relationships were present for MV and PV (figure 1, table 1).
- SEE was 0.08 $m.s^{-1}$ and 0.16 $m.s^{-1}$ in MV and PV, respectively.
- PV was higher than MV at all relative loads throughout the profile (figure 1).
- Individualised and pooled individualised LVPs demonstrated stronger correlations when compared to pooled data (table 1).
- Between-participants variation can be seen in figure 2. Moderate CVs (5-10%) were observed across all relative loads.
- MV and PV demonstrated high test-retest reliability in the full profiles across the three separate trials (ICC = 0.99; CV = 2.8-3.6%; TE = 0.04-0.06 $m.s^{-1}$).
- Within-participant reliability is presented in figure 3. All relative loads for both metrics met our criteria for high reliability (ICC > 0.7 and CV < 10%)
- TE was 0.03 to 0.07 $m.s^{-1}$ in both MV and PV.

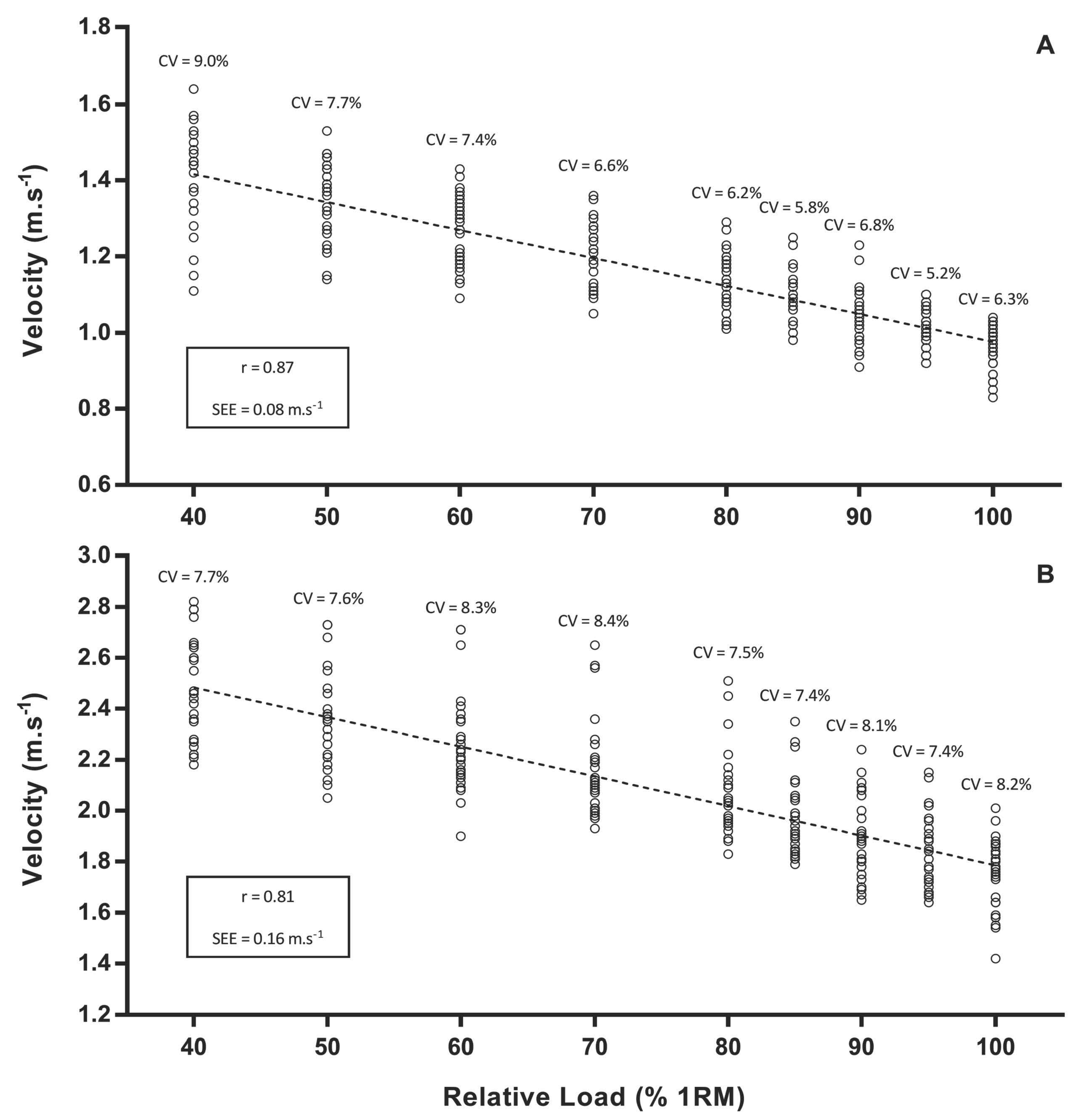


**Figure 2.** Between-participants variation for (A) mean velocity (m.s-1) and (B) peak velocity (m.s-1) for the power clean. Coefficients of Variation (CV) displayed above each relative load. --- represents linear regression line with *r* value + Standard Error of the Estimate (SEE) (m.s-1) values. *1RM* one repetition maximum.

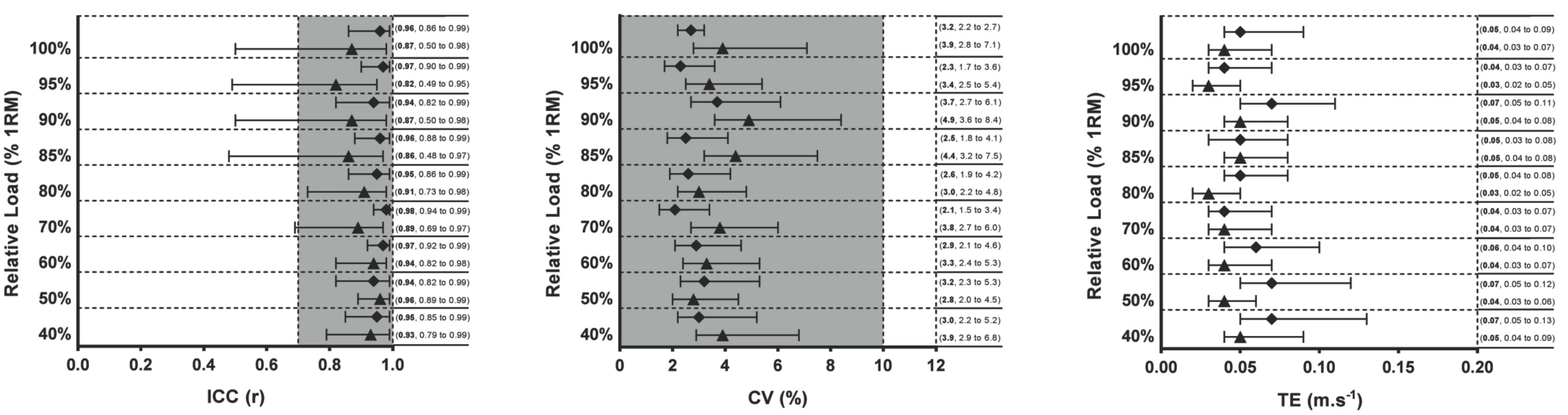


**Figure 3.** Within-participant reliability of mean velocity (m.s-1) (▲) and peak velocity (m.s-1) (◆) in the power clean at all submaximal relative loads. Forest plots displaying (A) Intraclass Correlations (ICC), (B) Coefficient of Variation (CV) and (C) Technical Error of Measurement (TE) with error bars indicating 95% confidence intervals. Right y axis details group mean and 95% confidence values. Grey shaded areas indicate the criteria for high reliability defined a priori. *1RM* one repetition maximum.

## 4. Conclusions

- Individualised LVPs presented stronger load-velocity relationships than pooled LVPs, suggesting load-velocity characteristics and neuromuscular recruitment differ across individuals, despite sample homogeneity.
- The power clean is highly reliable across all relative loads and therefore could be utilised by practitioners to measure strength capabilities.
- MV and PV produced similar reliability values, indicating either metric could be utilised.

## 5. Practical Applications

- Individualised LVPs could be utilised as an effective method of load prescription.
- Load-velocity profiling may allow for more accurate prescriptions by enabling coaches to adjust sessional loads, accounting for adaptations in strength or residual fatigue build up.
- The sensitivity demonstrated in the individualised LVPs provides confidence that an observed change in force-velocity characteristics will not be due to test-retest error.

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