A Meta-Analysis on the Effect of Complex Training on Vertical Jump Performance

by

Jeffrey Pagaduan¹, Haris Pojskic²

Complex training (CT) is a strength training intervention performed by completing all the sets of a resistance exercise followed by a series of high-velocity/plyometric exercise/s. The purpose of this novel study was to conduct a meta-analysis on the effect of CT on vertical jump (VJ) performance. Five electronic databases were searched using terms related to CT and the VJ. Studies needed to include randomized trials comparing CT with traditional resistance training (RT)/plyometric training (PLYO)/control (CON) lasting ≥ 4 weeks and the VJ as a dependent variable. Seven studies qualified for the meta-analysis with two studies differentiating VJ performance from CT and RT, two studies comparing VJ performance of CT and PLYO, and two studies establishing the difference in VJ performance between CT and CON. Results indicated similar improvement in VJ performance from CT and RT (p = 0.88). On the other hand, greater VJ performance in CT than PLYO was identified (ES = 0.86; 95% CI 0.24, 1.47; p = 0.01). CT also showed significantly greater enhancement in VJ compared to CON (ES = 1.14; 95% CI 0.60, 1.68; p < 0.01). In conclusion, CT can serve as alternative training from RT in improving VJ performance. On the other hand, CT is a better option in VJ enhancement than PLYO and CON.

Key words: vertical jump, countermovement jump, strength training, plyometrics.

Introduction

Designing strength training programs for power enhancement has been a constant challenge among practitioners. In the recent decade, complex training (CT) has been receiving a notable attention as one of the interventions for improving power (Carter and Greenwood, 2014; Ebben, 2002; Lesinski et al., 2014). CT is a strength training scheme that integrates resistance training and high-velocity/plyometric training in a single session. One variation of CT is performed by completing all the sets of a resistance exercise followed by a series of high-velocity/plyometric exercise/s (Ebben, 2002). The purpose of this novel study was to administer a meta-analysis on the effect of CT on vertical jump (VJ) performance.

Methods

Search Strategy

PRISMA guidelines for literature of databases (GoogleScholar, SPORTDiscus, World of Science, SpringerLink, and PubMed) were utilized from all time points until January 30, 2018 (Moher et al., 2009). The search terms and Booleans included (complex training) OR (contrast training) OR (combined weight training and plyometrics) OR (combined strength training and plyometrics) OR (combined resistance training and plyometrics) AND (vertical jump or jump performance). Manual searches from references were also carried out. Inclusion criteria were: 1) randomised trials peer-reviewed in English; 2) CT intervention that compared any resistance training (RT) or plyometric training (PLYO) or a control (CON) wherein COM involved completing all the sets of a resistance exercise succeeded by a series of high velocity/plyometric exercises; 3) availability of pre and post VJ data executed with a countermovement; and, 4) training intervention performed at least twice a week with duration of ≥
4 weeks.

**Data Extraction**

A single investigator (JP) who is a certified strength and conditioning specialist with more than 10 years of experience and holds a master’s degree in applied sport and exercise science assessed the eligibility of studies. In the first stage, titles and abstracts of identified articles were examined for relevance. Reference lists of included articles were also checked for possible inclusion. Full-text articles of potential studies were retrieved and assessed individually during the second stage. The second investigator (HP) who is an assistant professor specializing in sports training research independently checked the data extraction administered by JP. Both investigators rated the included studies for ‘risk of bias’ using an eight-point scale from the Consolidated Standards of Reporting Trials (CONSORT) statement where each item was answerable by 0 (absently or inadequately described) or 1 (explicitly described and present) (Altman et al., 2001). A score of 0-2 was regarded as having a high risk of bias, 3-5 with medium risk, and 6-8 considered as having a low risk of bias. A consensus between the first and second investigator was reached for any disagreement presented in data extraction and CONSORT output.

**Statistical Analysis**

A free meta-analysis tool (RevMan ver 5.3, The Nordic Cochrane Centre, Copenhagen) was utilized to examine VJ height in comparison with COM and RT/CON/PLYO. Standardized mean differences (difference in mean outcomes between groups/standard deviation of the outcome among participants) was used to derive effect size (ES) and interpreted with the following criteria: .2 – small effect; 0.5 - moderate effect; 0.8 – large effect (Cohen, 1988; Zlowodzki et al., 2007).

**Results**

The literature search uncovered 1067 potential articles and two articles were identified from reference lists. Removal of duplicates (n = 345) left 742 articles. After screening of the title and abstracts, 83 articles underwent a more detailed evaluation and led to the exclusion of 76, thus, leaving 7 articles for meta-analysis (de Villareal et al., 2011; Fayed, 2015; Ferrete et al., 2014; Franco-Márquez et al., 2014; Lyttle et al., 1996; Rodríguez-Rosell et al., 2017; Saeed, 2013). Figure 1 presents the flow diagram of study selection.

CONSORT scores of the seven studies in meta-analysis showed only one study scoring 5 (Rodríguez-Rosell et al., 2017). There were four studies that scored 4 (de Villareal et al., 2011; Ferrete et al., 2014; Franco-Márquez et al., 2014; Lyttle et al., 1996). Lastly, two studies scored 1 (Fayed, 2015; Saeed, 2013). Table 1 displays the CONSORT scores of the studies.

Participants determined in the meta-analysis involved thirty-nine physical education students, 33 regional athletes, and 151 young athletes with CT interventions administered twice to three times a week lasting from 6 to 12 weeks. Two studies compared CT and RT (de Villareal et al., 2011; Rodriguez-Rosell et al., 2017). Two studies differentiated between CT and PLYO (de Villareal et al., 2011; Lyttle et al., 1996), while six studies compared CT and CON (Fayed, 2015; Ferrete et al., 2014; Franco-Márquez et al., 2014; Lyttle et al., 1996; Rodriguez-Rosell et al., 2017; Saeed, 2013). The characteristics of studies are presented in Table 2.

**CT vs. RT**

There was no significant difference in VJ performance between CT and RT at $Z = 0.15, p = 0.88$.

**CT vs. PLYO**

CT posted significantly greater enhancement in VJ performance than PLYO, $Z = 4.15, p = 0.01$, ES = 0.86 [0.24, 1.47]. CT showed a 15.9% (95% CI 2.71 to 6.59 cm) increase in VJ performance, while PLYO posted an 8.89% (95% CI 0.84 to 4.66 cm) VJ attenuation. The funnel plot of CT vs. PLYO is displayed in Figure 3.

**CT vs. CON**

CT significantly improved VJ performance compared to CON at $Z = 4.15, p < 0.01$, ES = 1.14 [0.60, 1.68]. CT improved VJ performance by 8.8% (95% CI 1.48 to 4.74 cm), whereas CON showed a 2.11% (95% CI -0.94 to 2.06 cm) increase in VJ performance. Figure 4 exhibits the funnel plot of CT vs. CON. Pre and post VJ data from CT and a comparison group is depicted in Figure 4.
Discussion

The aim of this novel study was to conduct a meta-analysis on the effect of CT on VJ performance wherein CT was defined as completing all the sets of a resistance exercise succeeded by a series of high-velocity/plyometric exercise/s. Results revealed that CT exhibited similar improvement in VJ performance with RT. On the other hand, CT posted greater enhancement in VJ performance when compared with PLYO. Similarly, CT showed superior VJ gains than CON. Enhancement in VJ performance with CT compared to PLYO/CON may be related to the added stimulus in CT that facilitated postactivation potentiation (PAP) (Golaś et al., 2016; Robbins, 2005; Sale, 2002). PAP refers to the enhancement of performance from myosin phosphorylation and h-reflex excitation. In relation to this, VJ gains from CT may be related to cellular and hormonal adaptations favourable to power enhancement (Beaven et al., 2011; Labib, 2013). For example, Beaven et al. (2011) presented increased testosterone while enhancement in VJ performance after CT. Labib (2013) documented increased CD34/CD45 immune system stem cell secretion with improvement in the standing long jump after CT (Donovan and Koretzky, 1993; Sidney, 2014). It may be also possible that greater preservation of IIX muscle fibers is achieved with CT than PLYO/CON (Stasinaki et al., 2011). Greater selective recruitment of FTx muscle fibers in CT compared to PLYO/CON may have also occurred (Golaś et al., 2016). On the other hand, non-significant difference in VJ improvement exhibited between CT and RT may point to possible fatigue induced by CT which may have masked possible potentiation effects (Häkkinen, 1993; Wilson et al., 2013).

| Item 1 | Item 2 | Item 3 | Item 4 | Item 5 | Item 6 | Item 7 | Item 8 | Total |
|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| de Villareal et al., (2011) | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 4 |
| Fayed (2015) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Ferrete et al. (2014) | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 4 |
| Franco-Márquez et al. (2015) | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 4 |
| Lyttle et al. (1996) | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 4 |
| Rodríguez-Rosell et al. (2017) | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 5 |
| Saeed (2013) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |

**Item 1** - Were the groups comparable on baseline on key characteristics?
**Item 2** - Did the study include a true control group (randomised participants - not a comparison group)?
**Item 3** - Was the randomisation procedure adequately described and carried out? y
**Item 4** - Did the study report a power calculation and was the study adequately powered to detect intervention effects?
**Item 5** - Were the assessors blinded to treatment allocation at baseline and posttest?
**Item 6** - Did at least 80% of participants complete follow-up assessments?
**Item 7** - Did the study analyses account for potential differences at baseline?
**Item 8** - Did the study compute effect sizes?
### Table 2a

**Characteristics of Studies**

| References         | Participants                      | Training Modality                                                                 | Outcome (VJ Height)          |
|--------------------|-----------------------------------|------------------------------------------------------------------------------------|------------------------------|
| de Villarreal et al. (2011) | CT: 10M, F4; RT: 9M, 4F; PLYO: 9M, 3F | Participants aged 18-24 years, students performed complex training with... | CT: pre < post              |
|                    |                                    | CT: full squat (3-4 x 3-6 @ 60-80 RM) half-squat (3-4 x 2-6 @ MP to + 30% MP); loaded CMJ (3-4 x 2-5 @ MP to MP); rebound jumps (4-8 x 5 @ BW) | RT: pre vs. post : NSD       |
|                    |                                    | PLYO: rebound jumps (4-8 x 5 @ BW)                                                | PLYO: pre vs. post: NSD      |
|                    |                                    |                                                                                   |                              |
| Fayad (2015)       | CT: n = 10; CON: n = 10            | Participants aged 14-16 years, young swimmers performed complex training with... | CT: pre < post              |
|                    |                                    | CT: squat (3 x 12 RM) to vertical jump (3 x 10); bench press (3 x 12 RM) to... | CON: pre vs post: NSD        |
|                    |                                    | medicine ball pass (3 x 10); barbell lunge (3 x 12 RM) to step jump (3 x 10);... |                              |
|                    |                                    | lat pulldown (3 x 12 RM) to overhead ball pass (3 x 10); abdominal crunches... |                              |
|                    |                                    | (3 x 12 RM) to medicine ball sit up and throw (3 x 10); decline press... |                              |
|                    |                                    | (3 x 12 RM) to zigzag drill (3 x 10) regular training                              |                              |
|                    |                                    | CON: regular training NS; 8 wks                                                   |                              |
| Ferrete et al. (2014) | CT: n = 11; CON: n = 13             | Participants aged 8-10 years, young soccer players performed complex training with... | CT: pre < post              |
|                    |                                    | CT: 1/4 squat (2-3 x 6-8); 3 kg rebound jumps (3 x 4-6); full squat (3-5 x 6);... | CON: pre vs. post: NSD       |
|                    |                                    | partner resisted sprint (4 x 10 s); obstacle jump (3 x 5); sprint (4 x 20 m);... |                              |
|                    |                                    | soccer training 3x/wk; 8 wks                                                       |                              |
|                    |                                    | CON: soccer training 3x/wk; 8 wks                                                  |                              |

**CT** – complex training; **RT** – resistance training; **PLYO** – plyometric training; **CON** – control; **NS** – not stated; **NSD** – no significant difference; **VJ** – vertical jump; **CMJ** – countermovement jump; **RM** – maximal load in single repetition; **MP** – maximal power
**Table 2b**

| References | Participants | Training Modality | Outcome (VJ Height) |
|------------|--------------|-------------------|---------------------|
|            | N/sex | Age/discipline | Description | Frequency/ duration |
| Franco- et al. (2015) | CT: n = 22; 14-15 yrs | CT: full squat (2-3 x 4-8 @ 45-58 RM); CMJ | CT > CON |
|            | CON: n = 22 young soccer players | (3 x 5: weeks 2,4,6,8, 10,12 only); step phase triple jump (6 x 6-12); change of direction (3-5 x 10 s: weeks 1,3,5,7,9,11 only); sprint (3-4 x 20 m: weeks 2,4,6,8,10,12 only) | 2x/wk; 12 wks |
|            |        |                  | soccer training | 4x/wk; 12 wks |
|            |        |                  | match | 1/wk; 12 wks |
|            |        |                  | CON: soccer training | 4x/wk; 12 wks |
|            |        |                  | match | 1/wk; 12 wks |
| Lyttle et al (1996) | n = 33; 20-24 yrs | CT: bench press (1-3 x 6-10) to medicine ball | CT: pre vs. post; NSD PLYO: pre vs. post; NSD CON: pre vs. post; NSD |
|            | CT: 11M; various regional athletes | throw (1 x 1-2); squat (1-3 x 6-10) to depth jump (1 x 1-2) | 2x/wk; 8 wks |
|            | PLYO: 11 M; CON: 11 M | PLYO: bench press throws (2-6 x 8); squat jumps (2-6 x 6-8) | 2x/wk; 8 wks |
|            |        |                  | CON: no training | 8 wks |
## Table 2c

| References          | Participants | Age/discipline | Training Modality | Outcome (VJ Height) |
|---------------------|--------------|----------------|-------------------|---------------------|
| Rosell et al. (2017)| CT: 10M;     | semi-professional soccer | @ 45-60 RM); CMJ (3 x 5); change of direction (3-5 x 10 s); sprint (3-4 x 20 m) | 6 wks CT > CON |
|                     | RT: 10 M;    |                | soccer training   | 4 x/wk; 6 wks       |
|                     | CON: 10M     |                | match             | 1/wk; 6 wks         |
|                     |              |                | RT: full squat (2-4 x 3-6 @ 45-60 RM) | 2x/wk; 6 wks         |
|                     |              |                | soccer training   | 4x/wk; 6 wks        |
|                     |              |                | match             | 1/wk; 6 wks         |
|                     |              |                | CON: soccer training | 4x/wk; 6 wks       |
|                     |              |                | match             | 1/wk; 6 wks         |
| Saeed (2013)        | n = 20; CT: 10F; | 10-14 yrs young female volleyball players | CT: squat (3 x 12 RM) to vertical jump (3 x 10); bench press (3 x 12 RM) to medicine ball pass (3 x 10); barbell lunge (3 x 12 RM) to step jump (3 x 10); lat pulldown (3 x 12 RM) to overhead ball pass (3 x 10); abdominal crunches (3 x 12 RM) to medicine ball sit up and throw (3 x 10); decline press (3 x 12 RM) to zigzag drill (3 x 10) | 3x/wk; 9 wks CT: pre < post |
|                     | CON: 10F     |                | regular training  | NS; 9 wks           |
|                     |              |                | CON: regular training | NS; 9 wks           |
### Table 3

**VJ Performance in CT, PLYO, RT, and CON**

|                  | CT VJ (cm) | Comparison Group VJ (cm) |
|------------------|------------|--------------------------|
|                  | n Pre Post | n Pre Post               |
|                  | Mean ± SD  | Mean ± SD                |
|                  |            |                          |
| **RT**           |            |                          |
| de Villarreal et al. (2011) | 14 17.5 ± 2.60 21.2 ± 2.50 | 13 16.9 ± 3.00 19.9 ± 2.90 |
| Rodríguez-Rosell et al. (2017) | 15 37.8 ± 3.90 39.8 ± 4.20 | 15 36.3 ± 4.10 38.9 ± 4.70 |
| **PLYO**         |            |                          |
| de Villarreal et al. (2011) | 14 17.5 ± 2.60 21.2 ± 2.50 | 12 16.5 ± 2.80 18.2 ± 2.90 |
| Lyttle et al. (1996) | 11 52.8 ± 11.5 58.4 ± 9.30 | 11 50.8 ± 9.00 54.6 ± 8.50 |
| **CON**          |            |                          |
| Fayed (2015)     | 10 36.5 ± 1.61 41.2 ± 2.64 | 10 37.1 ± 1.75 38.7 ± 2.82 |
| Ferrete et al. (2014) | 11 22.3 ± 2.70 23.7 ± 3.50 | 13 20.2 ± 3.40 20.3 ± 3.20 |
| Franco-Márquez et al. (2015) | 22 33.2 ± 4.80 36.2 ± 6.50 | 22 33.2 ± 3.70 33.4 ± 3.70 |
| Lyttle et al. (1996) | 11 52.8 ± 11.5 58.4 ± 9.30 | 11 49.2 ± 3.50 49.2 ± 5.70 |
| Rodríguez-Rosell et al. 2017 | 15 37.1 ± 3.80 37.0 ± 4.20 | 15 37.0 ± 6.80 36.1 ± 5.90 |
| Saeed (2013)     | 10 22.3 ± 2.31 24.2 ± 2.12 | 10 21.1 ± 3.11 22.8 ± 2.64 |

### Table 4

**Subgroup Analysis for CT vs. CON**

| Group                      | Studies                                                                 |
|----------------------------|-------------------------------------------------------------------------|
| **Population Characteristics** |                                                                 |
| Age                        |                                                                         |
| ≥ 18 years                 | (Lyttle et al., 1996; Rodríguez-Rosell et al., 2017)                   |
| ≤ 18 years                 | (Fayed, 2015; Ferrete et al., 2014; Franco-Márquez et al. 2015; Saeed, 2013) |
| **CT Training Strategy**   |                                                                         |
| traditional                | (Fayed, 2015; Lyttle et al., 1996; Saeed, 2013)                        |
| non-traditional            | (Ferrete et al., 2014; Franco-Márquez et al., 2015; Rodríguez-Rosell et al., 2017) |

| Group                      | Studies                                                                 |
|----------------------------|-------------------------------------------------------------------------|
| **Population Characteristics** |                                                                 |
| Age                        |                                                                         |
| ≥ 18 years                 | (Lyttle et al., 1996; Rodríguez-Rosell et al., 2017)                   |
| ≤ 18 years                 | (Fayed, 2015; Ferrete et al., 2014; Franco-Márquez et al. 2015; Saeed, 2013) |
| **CT Training Strategy**   |                                                                         |
| traditional                | (Fayed, 2015; Lyttle et al., 1996; Saeed, 2013)                        |
| non-traditional            | (Ferrete et al., 2014; Franco-Márquez et al., 2015; Rodríguez-Rosell et al., 2017) |

| Group                      | Studies                                                                 |
|----------------------------|-------------------------------------------------------------------------|
| **Population Characteristics** |                                                                 |
| Age                        |                                                                         |
| ≥ 18 years                 | (Lyttle et al., 1996; Rodríguez-Rosell et al., 2017)                   |
| ≤ 18 years                 | (Fayed, 2015; Ferrete et al., 2014; Franco-Márquez et al. 2015; Saeed, 2013) |
| **CT Training Strategy**   |                                                                         |
| traditional                | (Fayed, 2015; Lyttle et al., 1996; Saeed, 2013)                        |
| non-traditional            | (Ferrete et al., 2014; Franco-Márquez et al., 2015; Rodríguez-Rosell et al., 2017) |

© Editorial Committee of Journal of Human Kinetics
Records identified through database searching \((n = 1067)\)

Additional records identified through other sources \((n = 2)\)

Records after duplicates removal \((n = 742)\)

Records screened \((n = 742)\)  Records excluded \((n = 659)\)

Full-text articles assessed for eligibility \((n = 83)\)  Full-text articles excluded, with reasons \((n = 76)\)

Studies included in meta-analysis \((n = 7)\)

Figure 1

Flow Diagram of the Search Process
Subgroup analysis was administered in CT vs. CON to determine possible moderators that led to superior VJ enhancement in CT. Researchers identified age (≥ 18 yrs vs. ≤ 18 yrs) and CT strategy (traditional vs. non-traditional) as covariates. It was found that both age groups exhibited greater VJ performance following CT than CON. However, no difference in VJ performance was observed between ≥ 18 yrs and ≤ 18 yrs in CT vs. CON. Furthermore, traditional and non-traditional CT modalities were analysed. Traditional CT involves a pair of exercises, while non-traditional CT is executed for 3 or more exercises. Utilizing traditional and non-traditional CT demonstrated greater VJ gains than CON. No difference in VJ enhancement was seen between traditional and non-traditional CT in CT vs. CON. Thus, age and CT strategy moderate VJ improvement in CT vs. CON. Subgroup analysis in CT vs. CON is presented in Table 4.

Limitations of this study are noteworthy of considerations. Firstly, heterogeneity in study designs with a small sample size involved in this study was observed. There was variety in complex training exercises, measurement of the VJ, and training populations. Thus, implications...
for the magnitude of inference from this study are limited. Subgroup analysis was only performed in CT vs. CON with few covariates due to scarcity of studies. Administration of such a method will help provide valuable insights into the findings of this study. The risk of bias of included studies ranged from high to moderate. Additionally, analysis utilizing comparison groups from other strength training schemes of similar volume (e.g. compound training, contrast loading) was not administered. Lastly, it should also be noted that only the VJ executed withcountermovement mechanics was included as a dependent variable.

In conclusion, enhancement of the VJ is achieved interchangeably from CT and RT. However, utilizing CT is more effective than PLYO or CON in improving VJ performance.

Acknowledgements
The authors would like to thank Brad Shoensfeld, PhD for his insights on the meta-analyses. All authors were involved from the project conception, to manuscript preparation.

References
Altman DG, Schulz KF, Moher D, Egger M, Davidoff F, Gøtzsche PC, Lang T; CONSORT GROUP (Consolidated Standards of Reporting Trials). The revised CONSORT statement for reporting randomized trials; explanation and elaboration. Ann Intern Med, 2001; 17: 663-694
Beaven CM, Gill ND, Ingram JR, and Hopkins WG. Acute salivary hormone responses to complex exercise bouts. J Strength Cond Res, 2011; 25: 1072–1078
Carter J, Greenwood M. Complex training re-examined: review and recommendations to improve strength and power. Strength Cond J, 2014; 36(2): 11-19
Cohen J. Statistical Power Analysis for the Behavioural Sciences. 2nd ed. Hillsdale, NJ: Lawrence Earlbaum Associates; 1988
de Villarreal ES, Izquierdo M, Gonzalez-Badillo JJ. Enhancing jump performance after combined vs. maximal power, heavy-resistance, and plyometric training alone. J Strength Cond Res, 2011; 12: 3274-3281
Donovan JA, Koretzky GA. CD45 and the immune response. J Am Soc Nephrol, 1993; 4(4): 976-985
Ebben WP. Complex training: A brief review. J Sports Sci Med, 2002; 1: 42–46
Fayed H. The effect of complex training on antioxidants, certain physical education and Record level of 50M crawl swimming for young swimmers. Sci Mov Health, 2015; 15(2): 379-385
Ferrete C, Requena B, Suarez-Arrones L, de Villareal ES. Effect of strength and high-intensity training on jumping, sprinting, and intermittent endurance performance in prepubertal soccer players. J Strength Cond Res, 2014; 28(2): 413-422
Franco-Márquez F, Rodríguez-Rosell D, González-Suárez JM, Pareja-Blanco F, Mora-Custodio R, Yañez-Garcia JM, González-Badillo JJ. Effects of combined resistance training and plyometrics on physical performance in young soccer players. Int J Sports Med, 2015; 36(11): 906-914
Golaś A, Maszczyk A, Zajac A, Mikolajec K, Stastny P. Optimizing post activation potentiation for explosive activities in competitive sports. J Hum Kinet, 2016; 52 95-106
Häkkinen K. Neuromuscular fatigue and recovery in male and female athletes during heavy resistance exercise. Int J Sports Med, 1993; 14(2): 53-59
Labib H. Effect of complex training on CD34/CD45 stem cells, certain physical variables and jump shoot performance for female handball. Sci Mov Health, 2013; 13(2): 215-221
Lesinski M, Muehlbauer T, Büsch D, Granacher U. Effects of complex training on strength and speed performance in athletes: a systematic review. Effects of complex training on athletic performance. Sportverletz Sportschaden, 2014; 28(2): 85-107
Lyttle AD, Wilson GJ, Otrowski KJ. Enhancing performance: maximal power versus combined weights and plyometrics training. J Strength Cond Res, 1996; 10(3): 173-179
Moher D, Liberati A, Tetzlaff J, Altman DG; The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med, 2009; 18: 264-269
Robbins D. Postactivation potentiation and its practical applicability: A brief review. J Strength Cond Res, 2005; 19: 453–458
Rodríguez-Rosell D, Torres-Torrelo J, Franco-Márquez F, González-Suárez JM, González-Badillo JJ. Effects of light-load maximal lifting velocity weight training vs. combined weight training plyometrics on sprint, vertical jump and strength performance in adult soccer players. *J Sci Med Sport*, 2017; 20(7): 695-699

Saeed KK. Effect of complex training with low-intensity loading interval on certain physical variables among volleyball infants (10-12 ages). *Sci Mov Health*, 2013; 13(1): 16-21

Sale DG. Postactivation potentiation: role in human performance. *Exerc Sport Sci Rev*, 2002; 30(3): 138-143

Stasinaki AN, Gloumis G, Spengos K, Blazevich AJ, Zaras N, Georgiadis G, Karampsos G, Terzis G. Muscle strength, power, and morphologic adaptations after 6 weeks of compound vs. complex training in healthy men. *J Strength Cond Res*, 2015; 29(9): 2259-2569

Sidney LE, Branch MJ, Dunphy S, Dua HS, Hopkinson A. Concise review: evidence for CD34 as a common marker for diverse progenitors. *Stem Cells*, 2014; 32(6): 1380-1389

Wilson JM, Duncan NM, Marin PJ, Brown LE, Loenneke JP, Wilson SM, Jo E, Lowery RP, Ugrinowitsch C. Meta-analysis of postactivation potentiation and power: effects of conditioning activity, volume, gender, rest periods, and training status. *J Strength Cond Res*, 2013; 27(3): 854-859

Zlowodzki M, Poolman RW, Kerkhoffs GM, Tornetta P 3rd, Bhandari M; International Evidence-Based Orthopedic Surgery Working Group. How to interpret a meta-analysis and judge its value as a guide for clinical practice. *Acta Orthop*, 2007; 78(5): 598-709

**Corresponding author:**

Jeffrey Pagaduan

College of Health and Medicine, School of Health Sciences, University of Tasmania – Newnham Campus, Tasmania, Australia

E-mail: jcpagaduan@gmail.com