Comparison of Flywheel versus Traditional Resistance Training in Elite Academy Male Rugby Union Players

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Abstract

This study investigated the effects of flywheel inertia training (FIT) vs traditional resistance training (TRT) over four-weeks in academy male rugby union (RU) players. 16 elite male academy RU players (age = 18.0 ± 1.0 years, body mass = 93.0 ± 13.1kg) were allocated into either FIT (n = 8) or TRT (n = 8) groups. Pre and post measures of countermovement jump (CMJ), squat jump (SJ) and drop jump (DJ) were completed. Relative peak force (PF), relative peak power (PP) and jump height (H) were measured for CMJ and SJ with reactive strength index measured for the DJ. Both groups showed improvements in all measures, except for SJ peak power, following TRT. Within-group analysis showed significant increases following TRT in CMJ-H (2.79cm, 90% CI = -0.70, 4.89cm; $p = 0.002$; ES = 0.51) and SJ-H (3.68cm, 90% CI = 1.25, 6.11cm; $p = 0.002$; ES = 0.88) with a significant improvement following FIT for CMJ-PP (1.96Wkg-1, 90% CI = -0.89, 4.80 Wkg-1; $p = 0.022$; ES = 0.55). No statistically significant between-group differences ($p > 0.05$) were evident. These findings suggest both FIT and TRT are effective for developing lower-body strength and power qualities in male academy RU players.

Introduction

Rugby union (RU) is a contact sport that involves high-intensity bouts of exercise exertion, contact, tackling, acceleration and scrummaging (Duthie, Pyne, Marsh, & Hooper, 2006). To meet the physical demands of RU, high levels of strength and power are required (Argus, Gill & Keogh, 2012). The development of these physical qualities is particularly important in academy RU players as these distinguish between playing levels (Jones et al., 2018) and age groups (Darrall-Jones, Jones, & Till, 2015). Therefore, to support the long-term athletic development (LTAD) of youth RU players the training of strength and power is necessary (Durguerian, Piscione, Mathieu & Lacome, 2019). Moreover, the specific targeting of these qualities becomes more vital as the youth athlete reaches adolescence as both during and after peak height velocity greater increases in strength and power occur (Moran et al., 2017). This can have important consequences for youth RU players since strength and power can also predict future senior level placings (Fontana, Colosio, Da Lozzo, & Pogliaghi, 2017). Consequently, the inclusion of training activities that maximises the development of strength and power in youth RU players is advocated (Till et al., 2020).

In youth athletes, the inclusion of resistance training (RT) has been shown to be highly effective for improving strength and power (Behm et al., 2017) as well as reducing injury risk (Soomro et al., 2016). Previous research investigating the effects of RT on strength and power in youth RU players has focused upon traditional resistance-training (TRT) in which equalised loads are used for both the concentric and eccentric phases of an exercise (Weakley et al., 2019; Smart & Gill, 2013; Harries, Lubans, Buxton, MacDougall, & Callister, 2018). However, this may provide a sub-optimal stimulus since greater forces are produced during eccentric muscle actions compared to concentric actions (Westing Seger, Karlson, Ekblom, 1988). Subsequently, the use of eccentric resistance training (ERT), to overload the eccentric phase of a given movement, is recommended (Wagle et al., 2017). This has importance for youth RU players as eccentric strength in academy RU players is associated with integral match activities such as sprinting (Bridgeman, McGuigan, Gill & Dulson, 2020). Also, the inclusion of lower-body eccentric injury prevention exercises has been reported to reduce injury incidence and severity in RU players (Evans and Williams, 2017). However, to the authors knowledge, previous research has not investigated the efficacy of ERT within this population.

Flywheel inertia training (FIT) is an effective ERT modality due to the accentuated eccentric muscle action that occurs from the energy stored in the flywheel system from the preceding concentric action (Martinez-Aranda & Fernandez-Gonzalo, 2017). Increases in strength and power in youth male adolescent team sport athletes following have been reported following 10-weeks of FIT (Raya-Gonzalez, Castillo, Domínguez-Díez & Hernández-Davó, 2021; de Hoyo et al., 2015). However, a limitation of these studies is that the control group did not complete any form of RT (Beato and Dello Iacono, 2020). Additionally, though Stojanović et al., (2021) reported greater improvements in power following eight-weeks of FIT compared to TRT in youth male basketball players, no differences in strength were observed. Furthermore, whilst increases in lower-body strength and power were found following six-weeks of FIT in adult RU players, both the experimental groups performed FIT but at just different intensities (Sabido, Pombero & Hernández-Davó, 2019). Consequently, the benefits of implementing FIT for youth male RU remains unclear. Since the development of physical qualities to optimise LTAD in young RU players is essential (Owen, Till, Weakley & Jones, 2020), further knowledge on the effects of ERT within this population will provide practitioners with important training guidance. Accordingly, the aim of this study was to investigate the effects of FIT, compared to TRT, on changes in lower-body strength and power in elite academy male RU players.

Methods

Study Design

A randomised-controlled trial, with a repeated measures design, was undertaken to assess lower-body strength and power changes following four-weeks of either TRT or FIT in elite academy RU players. Before and after the training intervention, measures of lower-body strength and power were assessed using the countermovement jump (CMJ), squat jump (SJ) and drop jump (DJ) tests. These tests were specifically chosen as they have been shown to be associated with performance measures and KPI's during RU match play (Cunningham et al., 2018) as well as sprint performance in RU players (Furlong, Harrison and Jensen, 2018). Training sessions were perfomed twice per week, in the evening, during the off-season period and were separated by 48-72 hours in line with players' training schedule. All participants achieved 100% compliance with the scheduled RT sessions. Testing sessions occurred at the same time of day (evening) to correspond with the participants normal training sessions.

Participants

An *a priori* power analysis (G*Power; University of Düsseldorf, Dusseldorf, Germany) was conducted to determine a minimum sample size for the study. Sample size was calculated on a power of (1-β) 0.90, an alpha error of 0.05 and an effect size of 0.58 based on previous research investigating the effects of FIT training in young male team sport athletes (de Hoyo et al., 2015). As a result, a minimum total sample size of 12 participants was required. Subsequently, 16 elite male academy RU players (age = 18.0 ± 1.0 years, body mass = 93.0 ± 13.1kg) volunteered to participate in the study. Players were randomly assigned to either TRT or FIT groups according to a computer generated sequence (www.randomizer.org). No control group was used (i.e. players who did not perform any training), since this would have resulted in an impractical approach that would not be representative of the participants training. Participants were physically active and were members of an elite club academy pathway with at least two years of RT experience within a supervised program. All participants were free from injury at the time of the intervention. After explaining the scope of the study, written informed consent was obtained from all players. Parental consent was obtained for participants under 18 years of age. The Hartpury University Research Committee provided ethical approval (ETHICS2019-77) prior to the beginning of testing, and the study was completed in accordance with the Declaration of Helsinki.

Procedures

Participants in the FIT group were familiarised with the flywheel device in the weeks leading up to the training intervention during their routine RT sessions. In the week before the start of the training intervention, both groups undertook baseline measures of jumping performance. All participants performed a standardised warm-up, similar to that which preceded their typical strength training programme, including lunge variations, mobility exercises and activation/potentiation exercises. Participants were familiar with the testing measures as these had been previously performed as part of their strength and power testing battery. Specifically, measures of bilateral CMJ, SJ and DJ were obtained. To collect all jumping measures, participants stood upon a force platform (Pasco, Rosedale, USA) sampling at 1000 Hz. A total of two trials were performed for each jump measure with each trial separated by a minimum of two minutes of rest. The same measures were again assessed upon completion of the training intervention.

Training Programme

The four-week training intervention was performed alongside the athletes' rugby training commitments. Both groups performed one upper-body, one lower-body and one total-body RT session per week. Both the TRT and FIT groups completed the same training volume of upper-body and lower-body exercises although the RT method for the lower-body exercises were dictated by the respective training conditions which the participants were allocated to. The FIT group performed all lower-body exercises on an inertial flywheel training device (K-box, Bromma, Sweden) including the squat, Romanian deadlift and Bulgarian split squat. Similarly, the TRT group performed the same exercises but used barbells for the back squat and Romanian deadlift exercises and dumbbells for the Bulgarian split squat exercise. These exercises were specifically chosen due to their inclusion within the athletes current training programme as well as their biomechanical similarity (i.e. lower body bilateral, lower-body unilateral, hip hinge). The loading for the FIT group was guided by previous research with increases in weekly training volume, rather than intensity, prescribed over the course of the training intervention (de Hoyo et al., 2015). A breakdown of weekly training volume during the meso-cycle can be viewed in Figure 1. An inertia flywheel intensity of 0.05 $kg \cdot m^2$ was used throughout the intervention and participants utilised a self-selected rest period between sets to ensure maximum performance. All training sessions were supervised by the club's strength and conditioning staff.

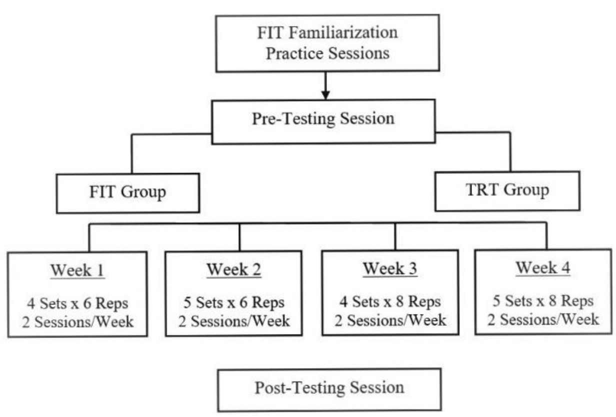

Figure 1. Overview of experimental procedures

Anthropometrics

Prior to performance testing, data on age and body mass was recorded. Participants' body mass was measured, using a calibrated electronic scale (SECA model 813, Birmingham, United Kingdom), to the nearest 0.1 kg.

Vertical Jumps

Participants started in a tall standing position on the dual-force platforms, with feet placed hip width to shoulder width apart and hands akimbo. If a participant removed their hands from the hips or flexed the knees during the jump, that jump was discarded and participants were asked to repeat the trial. Once in the correct starting position, participants were required to quickly descend into the countermovement position, to a self-selected depth, before immediately executing a maximal effort vertical jump and landing back in the start position on the force platforms (Van Hooren & Zolotarjova, 2017). The same protocol was completed for the SJ except that participants were required to slowly descend into their self-selected depth where they paused for three-seconds prior to performing the ascent phase of the jump (Van Hooren & Zolotarjova, 2017). Measures of relative concentric peak force ($N \cdot kg^{-1}$), relative concentric peak power ($W \cdot kg^{-1}$) and jump height (cm) were recorded for each effort with the average of the two trials used for further analysis.

Drop Jump

The drop jump (DJ) was performed from a box height of 0.40m. Participants were required to step off the box with hands akimbo and immediately rebound off the force platform with maximal intent, with emphasis also on minimising ground contact time whilst maximising jump height (Pedley, Lloyd, Read, Moore, & Oliver, 2017). Participants' technique was visually inspected for each trial and if technique was deemed incorrect, the trial was discarded and an additional trial performed. The average of the two accepted trials was recorded for further analysis.

Force Platform Analysis

All jumping measures collected were analysed using commercially available software (ForceDecks, Vald Performance Pty Ltd., Brisbane, Australia). The onset of movement was defined as the point when the total vertical ground reaction force (vGRF) deviated -20 N from body weight, and the take-off (TO) was set to the point when the total vGRF dropped below 20 N. Maximal vertical jump height (H) was calculated using the flight time method in which flight time was calculated as the time interval between take-off and touch down. Peak force (PF) and peak power (PP) values were defined as the highest values of force and power that were achieved during the concentric phase of the movement, respectively. Values for PF and PP were normalised to body mass to allow comparisons between groups and for any post intervention changes in body mass to be taken into consideration. To calculate RSI, jump height (cm) was divided by ground contact time (s).

Statistical Analysis

Statistical analysis was performed using JASP (version 13.1, University of Amsterdam, Amsterdam, Netherlands) with statistical significance set at $p < 0.05$. The normality of data was assessed via the Shapiro-Wilk test and visual inspection of the Q-Q plots with the homogeneity of variances tested using the Levene test. Within-session relative reliability was calculated using intraclass correlation coefficient (ICC), and absolute reliability was calculated via typical error expressed as a coefficient of variation

(CV%) ± 90% confidence limits using a customised Excel spreadsheet (Hopkins, 2015). Good and acceptable CV values were considered <5% and between 5% and 10%, respectively (Cormack, Newton, McGuigan & Doyle 2008). The ICC was interpreted in line with previous recommendations where values >0.90 = excellent, 0.75–0.90 = good, 0.50–0.75 = moderate, and <0.50 = poor (Koo & Li, 2016). A paired-samples t-test was used to evaluate within-group differences, and an analysis of covariance (ANCOVA) was performed to detect possible between-group differences, assuming baseline values as covariates. Due to sample size per group being below 20 participants, effect sizes (ES) for within-group changes and between-group differences were calculated using Hedges *g* (Goulet-Pelletier & Cousineau, 2018) by dividing the difference between groups' change scores by their pooled SD for each performance variable. ES were interpreted using previously outlined ranges; <0.19 = trivial, 0.2-0.59 = small, 0.6-1.19 = moderate, 1.2-1.99 = large and 2.0-4.0 = very large (Hopkins, Marshall, Batterham & Hanin 2009).

Results

Within-session reliability data are presented in Table 1 and show that data reported excellent absolute (ICC) and acceptable relative (CV%) reliability scores. Table 2 shows the changes in strength and power measures for both groups. Within-group analysis showed significant improvements in the TRT group for CMJ-H ($p = 0.002$, ES = *moderate*) and SJ-H ($p = 0.002$, ES = *moderate*). In the FIT group, a within-group significant improvement was found for CMJ-PP ($p = 0.022$, ES = *small*) with a trend for improvement in CMJ-H also noted ($p = 0.054$, ES = *small*). No statistically significant between-group differences ($p > 0.05$) were found for all measures. However, between-group standardised differences (Figure 2) showed greater improvements for TRT in CMJ-PF, CMJ-H, SJ-H and RSI whilst SJ-PP was greater for FIT. Figure 3 displays the individual changes in the TRT and FIT groups for all measures.

Table 1. Reliability data with 90% confidence intervals for pre and post tests in both traditional resistance training (TRT) and flywheel inertia training (FIT) groups.

	Baseline TRT		Post TRT		Baseline FIT		Post FIT	
Test	ICC	CV%	ICC	CV%	ICC	CV%	ICC	CV%
CMJ-PP	0.97 (0.97-0.99)	1.14 (0.80-2.40)	0.98 (0.92-0.99)	1.83 (1.29-3.30)	0.96 (0.84-0.99)	1.83 (1.29-3.29)	0.95 (0.77-0.99)	1.92 (1.35-3.44)
CMJ-PF	0.99 (0.77-0.99)	2.41 (1.70-4.32)	0.95 (0.78-0.99)	2.97 (2.10-5.34)	0.98 (0.90-0.99)	2.05 (1.45-3.68)	0.93 (0.66-0.98)	3.48 (2.46-6.26)
CMJ-H	0.98 (0.90-0.99)	2.62 (1.85-4.71)	0.99 (0.96-0.99)	1.69 (1.19-3.04)	0.97 (0.85-0.99)	2.84 (1.99-5.08)	0.98 (0.90-0.99)	1.89 (1.33-3.40)
SJ-PP	0.90 (0.52-0.98)	5.20 (3.67-9.34)	0.98 (0.91-0.99)	2.19 (1.54-3.93)	0.96 (0.83-0.99)	2.76 (3.41-4.96)	0.99 (0.96-0.99)	1.98 (1.39-3.55)
SJ-PF	0.96 (0.81-0.99)	2.65 (1.87-4.76)	0.95 (0.75-0.99)	2.14 (1.51-3.85)	0.95 (0.76-0.99)	2.23 (1.57-4.00)	0.92 (0.64-0.98)	2.44 (1.72-4.39)
SJ-H	0.98 (0.92-0.99)	2.11 (1.49-3.79)	0.98 (0.93-0.99)	2.31 (1.63-4.14)	0.97 (0.87-0.99)	2.47 (1.75-4.42)	0.99 (0.96-0.99)	0.87 (0.61-1.56)
RSI	0.99 (0.98-0.99)	1.51 (1.06-2.71)	0.98 (0.93-0.99)	3.42 (2.41-6.14)	0.99 (0.97-0.99)	2.05 (1.54-4.10)	0.96 (0.81-0.99)	5.64 (3.98-10.14)

ICC = intraclass correlation coefficient; CV% = coefficient of variation; CMJ-PP = countermovement jump relative peak power; CMJ-PF = countermovement jump relative peak force; CMJ-H = countermovement jump height; SJ-PP = squat jump relative peak power; SJ-PF = squat jump relative peak force; CMJ-H = squat jump height; RSI = reactive strength index.

Table 2. Baseline vs Post Intervention Changes in Strength and Power Measures for Traditional (TRT) and Flywheel Inertia Training (FIT) Groups.

	TRT (n = 8)				FIT (n = 8)				Between Group Differences	
Variables	Baseline	Post	Difference (90% CI)	Effect Size (90% CI)	Baseline	Post	Difference (90% CI)	Effect Size (90% CI)	F	p
CMJ-PP (W·kg^{-1})	50.59 ± 6.04	52.85 ± 5.43	2.26 (-0.58-5.11)	0.39 (-0.46, 1.20)	48.70 ± 3.53	50.66 ± 3.23	1.96 (-0.89 4.80)	0.55 (-0.29, 1.39)*	0.145	0.710
CMJ-PF (N·kg^{-1})	22.18 ± 1.77	23.11 ± 2.35	0.93 (-0.61, 2.47)	0.42 (-0.41, 1.25)	24.65 ± 2.26	25.10 ± 2.40	0.45 (-1.09, 1.99)	0.18 (-0.64, 1.01)	0.356	0.561
CMJ-H (cm)	36.66 ± 4.92	39.45 ± 5.36	2.79 (-0.70, 4.89)	0.51 (-0.32, 1.35)*	36.64 ± 4.31	38.45 ± 3.64	1.81 (-0.29, 3.90)	0.43 (-0.40, 1.26)	1.031	0.328
SJ-PP (W·kg^{-1})	50.48 ± 6.02	50.19 ± 5.98	-0.29 (-6.38, 5.80)	-0.05 (-0.87, 0.78)	46.98 ± 4.94	51.24 ± 7.95	4.27 (-1.82, 10.36)	0.22 (-0.60, 1.05)	1.627	0.224
SJ-PF (N·kg^{-1})	20.75 ± 1.99	21.25 ± 1.44	0.50 (-0.81, 1.82)	0.27 (-0.55, 1.10)	20.98 ± 1.52	21.40 ± 1.39	0.42 (-1.71, 3.02)	0.27 (-0.55, 1.10)	2.454	0.988
SJ-H (cm)	35.63 ± 4.23	39.31 ± 5.53	3.68 (1.25, 6.11)	0.88 (0.02, 1.74)*	34.89 ± 3.89	36.54 ± 2.63	1.65 (-0.78, 4.08)	0.47 (-0.36, 1.30)	3.292	0.093
RSI	1.97 ± 0.35	2.22 ± 0.47	0.25 (-0.16, 0.65)	0.57 (-0.27, 1.41)	1.94 ± 0.40	2.07 ± 0.42	0.13 (-0.27, 0.54)	0.30 (-0.53, 1.13)	0.436	0.521

CMJ-PP = countermovement jump relative peak power; CMJ-PF = countermovement jump relative peak force; CMJ-H = countermovement jump height; SJ-PP = squat jump relative peak power; SJ-PF = squat jump relative peak force; SJ-H = squat jump height; RSI = reactive strength index; CI = confidence interval; * = within-group statistical significance (p < 0.05).

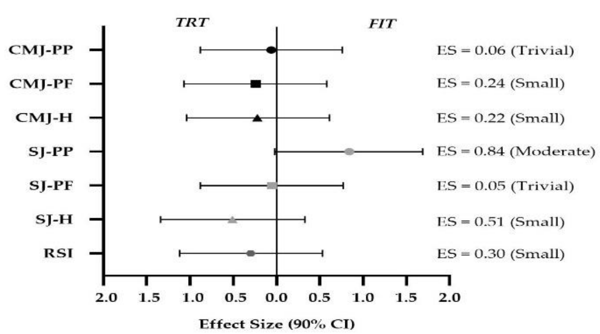

Figure 2. Between group standardised differences with 90% Confidence Intervals for Traditional Resistance Training (TRT) vs Flywheel Inertia Training (FIT).

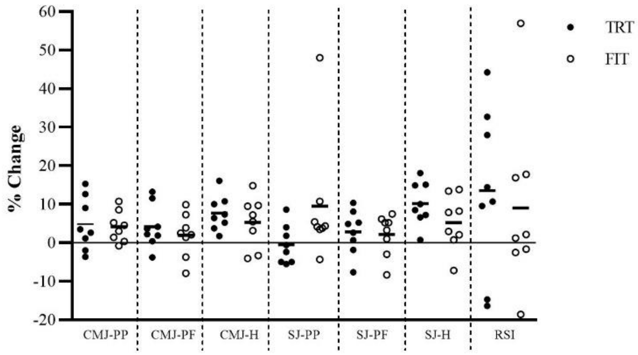

Figure 3. Individual % changes in all strength and power measures following the four-week training intervention in both Traditional Resistance Training (TRT) and Flywheel Inertia Training (FIT) groups.

Discussion

This study investigated the effects of FIT compared to TRT in elite male academy RU players. Our findings showed that both FIT and TRT were effective in increasing lower-body strength and power measures following a four-week off-season RT programme. However, despite no between-group statistically significant differences, the magnitude of the changes tended to favour the TRT group to a small effect for all measures except SJ-PP. Overall, our findings suggest that both TRT and FIT improve lower-body strength and power qualities in elite academy male RU players to a similar extent.

The increases in vertical jump performance over four-weeks in the TRT group in our study are similar to those previously reported in male academy RU players following between 12-15 weeks of TRT (Harries et al., 2018; Smart & Gill, 2013; Weakley et al., 2019). Our changes, which occurred in a shoter time period, may be explained by the elite playing status of our participants. Indeed, factors such as training age (Till, Darrall-Jones, Weakley, Roe & Jones, 2017) and strength level (Cormie, McGuigan & Newton,

2010) have been shown to influence changes in strength and power following RT. Alternatively, whilst the FIT group showed increases in all vertical jump measures these were smaller compared to those recently reported after ten-weeks in young elite male soccer players (Raya-González et al., 2021) and eight-weeks in elite adolescent male basketball players (Stojanović et al., 2021). Similar to the aforementioned studies though, our participants had no previously exposure to FIT. Therefore, our smaller increases are likely explained by the shorter training intervention we used since a longer training duration and more training sessions have a greater effect on adaptations to RT in adolescent males (Moran et al., 2017). Overall, our findings demonstrate that in well-trained youth male adolescent athletes, increases in lower-limb strength and power measures can occur within as litte as four-weeks following either TRT or FIT.

Whilst limited research exists examining the effects of TRT or ERT in academy rugby players on RSI, our changes are greater than those previously reported within a similar population. Douglas et al., (2018) reported *trivial* changes after four-weeks of either lower-body TRT (ES = 0.07) or accentuated eccentric loading (ES = -0.03) in resistance-trained academy RU players (19.4 years). In contrary to our study though, participants competed in weekly pitch-based training and match play which may have negatively impacted training adaptations. Indeed, previous research in RU athletes has found that the concurrent training prescription of both RT and endurance can impair strength improvement (Robineau, Babault, Piscione, Lacome & Bigard, 2016). Interestingly though, despite our participants training programme not including plyometric exercises, the improvements in RSI are similar to those reported (ES = 0.58) in young male collegiate RU players following six-weeks of plyometric training (Jeffreys et al., 2019). Since the RSI is associated with both concentric (Beattie, Carson, Lyons & Kenny, 2017) and eccentric (Kipp et al., 2018) forces, it is likely that both RT methods can positively influence performance. Thus, our results would suggest that both TRT and FIT are useful strategies for enhancing RSI in male academy RU players.

Although we reported no statistically significant between-group differences, between-group standardised differences marginally favored TRT. The lower effects for FIT may be related to the novelty of the ERT stimulus for the participants. Tous-Fajardo, Maldonado, Quintana, Pozzo & Tesch (2006) showed that individuals with more experience of FIT achieved greater eccentric and concentric peak forces than athletes of the same caliber who were novices to the exercise. Therefore, whilst our participants were familiarised with the FIT device, the short-term nature of our intervention may have limited its effectiveness compared to TRT. Additionally, the training intervention prescribed for the FIT group may have not been optimal due to their limited prior exposure to ERT. Stojanović et al., (2021) only included two flywheel exercises per session with a frequency of one to two times per week and a maximum of four sets per exercises, in which their participants, like ours, had not performed FIT previously. Therefore, our participants may have benefited from a less progressive training programme to facilitate adequate recovery and adaptation. Indeed, regular intense eccentric training in novice individuals has been shown to not allow for complete repair of muscle damage which subsequently impairs strength (Krentz & Farthing, 2010).

Our study is not without limitations. Firstly, as our data was collected from a small sample size, the results are generalizable only to similar samples of subjects and levels of competition. Secondly, due to the training intervention taking place within the off-season it was not within the scope of this study to investigate the effects of FIT on field-based measures of performance such as sprint speed and COD. However, such measurements could have provided further information regarding the transfer of FIT to sport specific RU tasks as greater improvements in speed and COD have been shown after FIT compared to TRT (Maroto-Izquierdo, García-López, & De Paz, 2017). Finally, whilst the focus of our study was on the lower-body, future research should also investigate the effects of upper-body FIT. This may have important implications for both performance and injury prevention for RU players since the upper-body is heavily involved in physical contact (i.e. tackling, scrums, fending, rucks and mauls) during training sessions and competition (Twist, Waldron, Highton, Burt & Daniels, 2012).

Conclusion

Our findings have important implications for practitioners working with elite male academy RU players. Considering the importance of developing strength and power in young male RU players, the training interventions used here provide guidance on the TRT and FIT methods that can be used to enhance these qualities. Whilst our findings showed that TRT may, overall, be favorable to FIT, it is important to note that the magnitude of this was marginal and therefore both are valuable RT methods to incorporate into training to improve lower-body strength and power. Future research investigating FIT in youth male athletes should examine the effects of different training prescription factors (e.g. intensity, volume, frequency) and the concurrent integration of both FIT and TRT to optimise strength, power and speed.

Disclosure Statement

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