Effects of a short-term pre-season training programme on the body composition and anaerobic performance of professional rugby union players

Argus, Christos K; Gill, Nicholas; Keogh, Justin; Hopkins, Will G; Beaven, C Martyn

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EFFECTS OF A SHORT-TERM PRE-SEASON TRAINING PROGRAM ON THE BODY COMPOSITION AND ANAEROBIC PERFORMANCE OF ELITE RUGBY UNION PLAYERS

Running Head: Pre-season training in elite rugby union athletes.

Key Words: STRENGTH, POWER, FATIGUE, BODY COMPOSTION.

Abstract

Pre-season rugby training develops the physical requisites for competition and consists of a high volume of resistance training and anaerobic and aerobic conditioning. The purpose of this investigation was to determine the effects of a four week pre-season on 33 elite rugby union players. Bench press and box squat increased moderately (13.6 kg, 90% confidence limits ±2.9 kg and 17.6 ±8.0 kg, respectively) over the training phase. Small decreases in bench throw (70.6 ±53.5 W), jump squat (280.1 ±232.4 W) and fat mass (1.4 ±0.4 kg) were observed. Additionally, small increases occurred in fat free mass (2.0 ±0.6 kg) and flexed upper-arm girth (0.6 ±0.2 cm). While moderate increases occurred in mid-thigh girth (1.9 ±0.5 cm) and perception of fatigue (0.6 ±0.4 units). Increases in strength and body composition can be made in elite rugby union athletes in as little as four weeks of intensive pre-season training, but may be the result of returning to previous fitness levels prior to the off-season. Decreases in power may reflect high training volumes and increases in perceived levels of fatigue.

Introduction

Elite rugby union athletes compete in matches throughout a calendar year. As a consequence, it is common for the athlete to have a limited time to prepare for the physical aspects of the game between each separate competition e.g. international test matches, Super 14 and provincial representation. Short training phases prior to the beginning of each separate competition (pre-season) provide conditioning coaches and athletes with small opportunities to significantly enhance aspects of physical conditioning. In most instances this time period ranges from two to six weeks before the athletes are required to compete on a weekly basis again. Once competition commences, the volume of conditioning training is reduced while the volume of specific rugby training sessions (e.g. tactical and skill sessions) is increased. Improvements in specific areas of physical conditioning during these competitive phases will be limited by the brevity of these training blocks (O'Connor & Crowe, 2007). It is therefore imperative that the programming during this phase is as effective as possible.

In elite rugby union athletes, pre-season training normally consists of a high volume, high intensity training regime that incorporates the multi-faceted aspects of physical conditioning. The goals of the pre-season training phase are to increase aerobic and anaerobic fitness, speed, strength and power, and improve body composition (increase lean mass, decrease fat mass). To achieve these goals, athletes typically train multiple aspects of performance concurrently, which may compromise physical adaptation (Kraemer et al., 1995). To date there is no literature examining the effects of a pre-season training phase in professional rugby union athletes, and therefore the magnitude of improvement that can be expected during short phases of high volume, high intensity training is unknown. Currently programming for a pre-season training phase for elite rugby union athletes is based primarily on personal experience and/or anecdotal evidence (including non-specific literature, e.g. novice or strength trained athletes). Knowledge from investigating such short term training phases will provide strength and conditioning practitioners with data regarding magnitude of change and the rate of change in specific performance measures, potentially enhancing programming strategies for athletes during a complete calendar year.

Very little literature has examined the magnitude of improvement achievable over a pre-season in elite athletes in similar football codes. In elite rugby league athletes, significant increases in strength (bench press ~13%, deadlift ~19%) have been reported in pre-season training phases of up to six weeks (O'Connor & Crowe, 2007; Rogerson et al., 2007). Contrasting findings have been reported in power development during a pre-season in elite rugby league athletes. O’Connor and Crowe (2007) reported significant increases in peak power (3%) during a 10s cycle ergometer test over the six week training phase. In contrast, Harris and colleagues (2008) reported a significant decrease in peak power (~17%) as assessed by machine jump squats following a seven week pre-season. Unfortunately, Harris and colleagues (2008) did not detail any additional training that athletes were performing during the training phase, making comparisons between the investigations difficult. It may be likely that increased levels fatigue caused by high volume and intensity training throughout the seven week phase may have lead to reductions in power (Jurimae, Purge, Maestu, & Jurimae, 2002). Limited findings have also been reported in changes in body composition over a pre-season. O'Connor and Crowe (2007) reported a significant decrease in sum of eight skinfolds (approximately 6%), while Rogerson and colleagues (2007) reported significant increases in fat free mass over similar length pre-seasons in elite rugby league players. Although there are similarities between rugby union and rugby league, there are also many differences including duration of work periods, type of work (dynamic or static), work : rest ratios, differences in the time spent at maximal and sub-maximal intensities, distances covered (m) throughout the game, etc (Deutsch, Kearney, & Rehrer, 2007; Duthie, Pyne, & Hooper, 2003, 2005; Gabbett, 2005; Meir, Colla, & Milligan, 2001). Due to such differences, making direct comparisons between the rugby codes may be misleading. Therefore is need for a rugby union pre-season to be assessed.

By monitoring and assessing changes in anthropometric and performance measures over a pre-season training phase, conditioning coaches may be better able to determine the quality and effectiveness of training. A detailed analysis of the effects of a short term training phase on the players' body composition, strength and power may provide value by improving our understanding of the magnitude of the potential adaptation in such measures. Therefore the aim of this investigation was to determine the effects of a four week pre-season on strength, power, body composition and fatigue.

Methods

Participants

Thirty three elite rugby union players from a Super 14 professional rugby team volunteered to take part in this study (mean ± SD; age, 24.8 ± 2.4 years; stature, 186.2 ± 6.1 cm; mass, 102.3 ± 10.3 kg). Each athlete had undergone at least two years of intensive and regular resistance training exercise, and must have been competing in a prior national or international competition to be included in this study. Each player was informed of the risks and benefits of the study and signed consent forms. This study was approved by the Auckland University of Technology Ethics Committee.

Study design

Following a six week reduced volume maintenance phase (off-season), participants began an intense four week training phase (pre-season) with the goal to increase strength, power, and muscle mass, while decreasing fat mass and improving aerobic and anaerobic fitness. During the first day of the training phase an anthropometric profile of the participants was conducted. Participants were then tested for upper-body and lower-body strength (bench press and box squat). On the second day participants were tested for upper-body and lower-body power (bench throw and jump squat). Players were reassessed on these same measures on the second to last day (Thursday; strength assessment) and last day of training (Friday; body composition and power assessment) in week four. Additionally 26 athletes also completed the recovery-stress-questionnaire (RESTQ) on the first and last day of the training phase to determine changes in self-reported fatigue. Due to time constraints and additional commitments of the professional athlete, seven participants did not complete the RESTQ.

Body composition

International Society for the Advancement of Kinanthropometry (ISAK) protocols were used to determine the anthropometric profile of the rugby players (Norton et al., 1996). Measurement included body mass, stretch stature, eight skinfolds (triceps, subscapular, biceps, iliac crest, supra iliac, abdominal, thigh, calf), and three limb/body girths (flexed upper arm, chest, mid thigh). Fat mass was estimated using the prediction equation by Withers and colleagues (1987). Fat free mass was calculated by subtracting fat mass from body mass. Girth measurements reported were adjusted for the removal of skinfold thickness and were calculated by assuming the body segment to be a cylinder and multiplying the skinfold thickness (in cm) by π and subtracting the value from the measured girth. The technical error of measurement (TEM) for each skinfold site and girth measurement was: triceps, 3.4%; subscapular, 3.5%, biceps, 3.1%, iliac crest, 2.1%, supraspinale, 3.3%, abdominal 1.8%, front thigh, 1.9%, medial calf, 2.5%, arm girth (flexed and tensed), 0.3%, chest girth, 0.7%, and mid thigh girth, 0.6%. All TEM's were below upper limits recommended (Perini, de Oliveira, Ornellas, & de Oliveira, 2005).

Strength assessment (bench press and box squat)

Strength was assessed using the bench press and box squat exercises using methods previously outlined (Argus, Gill, Keogh, Hopkins, & Beaven, 2009). Briefly, each participant was required to perform three sub-maximal sets (two-six repetitions; 50%, 70%, 90% of perceived maximum strength) prior to one maximal set (100% effort) of two-four repetitions. Each set was separated by a two minute rest period. For the bench press participants used a self selected hand grip and lowered the bar to approximately a 90° angle at the elbow. During the box squat participants used a self-selected foot position and were required to lower themselves to a sitting position briefly on the box and then return to a standing position. The box height was adjusted for each athlete to allow the top of the thighs to be parallel to the floor while in the seated position. Each maximal set was used to predict the participant's one repetition maximum (1RM). The coefficient of variation (CV %) for bench press and box squat was assessed in ten professional rugby players assessed one week apart and were 4.3% and 4.6%, respectively. The following equation was used to predict bench press (r=0.993) and box squat (r=0.969) 1RM (Lander, 1985; LeSuer, McCormick, Mayhew, Wasserstein, & Arnold, 1997):

$$1RM \quad = \quad (100 \times weight)/(101.3-(2.67123 \times reps))$$

Power assessment

Bench throw

Upper-body power was assessed using a bench throw exercise performed in a Smith machine (CV=5.0%). The warm-up consisted of two sets of four repetitions bench press at 50% of 1RM bench press. Participants then completed one set of four repetitions of bench throws at 50% and 60% 1RM bench press (Argus et al., 2009) as maximum muscular power in the bench press throw appears to be produced at these loads in elite strength trained rugby league athletes (Baker, Nance, & Moore, 2001a). Participants used a self selected hand position and depth throughout the movement. Participants were required to press the bar as explosively as possible trying to propel the bar for maximum height. Three minutes rest was allowed between each set.

Jump squat

Lower-body power was assessed using a jump squat exercise performed in a Smith machine (CV=4.8%). The warm-up consisted of two sets of four repetitions squat (i.e. lowering the bar to a 90° knee angle) using a load of 55% of 1RM box squat. Participants then completed one set of four repetitions jump squat at 55% and 60% 1RM box squat (Argus et al., 2009) as maximum muscular power in the jump squat appears to be produced at these loads in elite strength trained rugby league athletes (Baker, Nance, & Moore, 2001b). Participants used a self selected foot position and lowered the bar to a self selected depth throughout the movement. Participants were required to jump as explosively as possible aiming for maximum height. Three minutes rest was allowed between each set.

Power produced during each bench throw and jump squat repetition was quantified with a Gymaware™ optical encoder (50 Hz sample period with no data smoothing or filtering; Kinetic Performance Technology, Canberra, Australia) (Drinkwater, Galna, McKenna, Hunt, & Pyne, 2007). Validity of the Gymaware™ optical encoder has been previously reported elsewhere (Drinkwater et al., 2007). For the jump squat only, system mass (weight of the bar plus bodyweight) was used for the calculation of power (Dugan, Doyle, Humphries, Hasson, & Newton, 2004).

Fatigue assessment

Athletes completed the RESTQ on the first and last day of the training phase so that (subjective) levels of fatigue could be assessed (Jarimae, Maestu, Purge, & Jarimae, 2004). Briefly, the RESTQ consists of 77 items and allows analysis of 19 scales such as general stress, emotional stress, and fatigue. Athletes answered all 77 items, however for the purpose of this investigation only responses relating to fatigue were analysed as it has been suggested that levels of fatigue may have an affect on physiological adaptation (Harris et al., 2008).

Training

Participants performed the training phase (pre-season) over a period of four weeks. Training was performed on three days (Wednesday-Friday) in week one; four days (Monday-Thursday) in week two; and five days (Monday-Friday) for weeks three and four.

Training consisted of resistance training sessions (45-60 min; Hypertrophy, 4 sets of 8-12 RM, 90 s rest for 5 exercises; Strength, 3-7 sets of 2-6 RM, 3 min rest for 4-6 exercises; Power, 3 sets of 4-6 reps at 50-70% 1RM, 2 min rest for 4-6 exercises; and Circuit Training, 6-12 reps, 30 s rest for 10 exercises), aerobic conditioning sessions (20-60 min; efforts of >2 min; swimming, cycling, rowing, conditioning games, orienteering), anaerobic conditioning sessions (45-60 min; repeated efforts of 5-45s duration, 1:1-2 work to rest; boxing, hill sprints, repeated speed), and rugby specific training (45-60 min; defensive patterns, team plays) (

Table 1). Following each session, all players rated their ratings of perceived exertion (RPE) using the ten point Borg scale (Borg, 1982).

****Table 1 near here****

Throughout the four week training phase participants performed 53 sessions in total (3.1 sessions per training day) at an average RPE of 7.4. Resistance training accounted for 38% of the total number of training sessions (Table 2).

****Table 2 near here****

Statistical analyses

Strength, power and anthropometric characteristics were log-transformed to reduce non-uniformity of error, and the effects of the training phase were derived by back transformation as percent changes (Hopkins, 2006). Due to the uniformity of the fatigue data, it was analysed without transformation.

Standardised changes in the mean of each measure were used to assess magnitudes of effects by dividing the changes by the appropriate between-athlete standard deviation. Standardised changes of <0.2, <0.6, <1.2, and <2.0 were interpreted as trivial, small, moderate, and large effects, respectively (Snowling & Hopkins, 2006), a modification of Cohen's thresholds of 0.2, 0.5, and 0.8 (Cohen, 1988); the modifications are based primarily on congruence with Cohen's thresholds for correlation coefficients. To make inferences about true (large-sample) value of an effect, the uncertainty in the effect was expressed as 90% confidence limits. The effect was deemed unclear if its confidence interval overlapped the thresholds for small positive and negative effects (Batterham & Hopkins, 2006).

Results

Increases of 13.6 kg (90% Confidence limits ±2.9 kg) and 17.6 kg (±8.0 kg) were observed in bench press and box squat strength respectively over the four week pre-season training phase indicating a positive training effect (2.7% and 2.8% on average per week, respectively). However, a decrease of 70.6 W (±53.5 W) and 280.1 W (±232.4 W) occurred in bench throw and jump squat power, respectively. Magnitudes and the average weekly change for all variables are reported in Table 3.

Over the four week training phase there were small reductions in the sum of eight skinfolds (11.0 ±2.7 mm) and fat mass (1.4 ±0.4 kg). Small increases were observed in fat free mass (2.0 ±0.6 kg) and flexed upper-arm girth (0.6 ±0.2 cm). A moderate increase in mid-thigh girth (1.9 ±0.5 cm) and a trivial increase occurred in chest girth (0.5 ±0.9 cm) was also observed over the four week pre-season. Fat free mass, flexed upper-arm girth, chest girth and mid-thigh girth increased by 0.7%, 0.4%, 0.1%, and 0.9% on average per week, respectively. Fatigue levels increased moderately from the start to the end of the training phase (0.6 ±0.4 units).

****Table 3 near here****

Discussion

The primary purpose of this investigation was to determine the effects of a pre-season training phase on strength, power and body composition in elite rugby union athletes. Findings indicate that strength in both the upper- and lower-body can be improved over a four week pre-season training phase of high volume concurrent training. In contrast, levels of upper- and lower-body power may be negatively affected by the same training regime. Over the four week training period, small decreases in fat mass were observed in conjunction with a small increase in fat free mass, and flexed upper-arm girth and moderate increases in mid thigh girth.

Strength

Moderate increases in bench press 1RM (13.6 kg) and box squat 1RM (17.6 kg) were observed over the training phase. Athletes 1RM strength in the current study (baseline bench press 124 kg, baseline box squat 155 kg) was similar to or greater than previously reported in elite rugby union athletes, confirming their well trained status (131 kg bench press and 150 kg box squat) (Beaven, Gill, & Cook, 2008) (Beaven, Gill, Ingram, & Hopkins, In Press).

Previous literature has reported enhanced strength improvements with increased frequency of training. Hoffman and colleagues (1990) reported that five sessions per week produced superior performance enhancements than three, four, or six sessions per week. It is likely that five sessions per week provided optimal loading to for adaptation to occur, while six sessions may have compromised adaptation due to inadequate recovery and increased residual fatigue (Harris et al., 2008; Jurimae et al., 2002). The current investigation utilised on average five sessions per week which produced larger increases in strength than those that have conducted a similar length pre-season training phase utilising up to four sessions per week (O'Connor & Crowe, 2007; Rogerson et al., 2007). Therefore there appears to be a dose response relationship to performance improvements. However, there may be a limit to the frequency of training that produces positive adaptation.

Increases in strength may also be due to hypertrophy of the musculature. A small increase in lean muscle mass, flexed upper-arm girth and a moderate increase in mid-thigh girth were observed over the training phase. Increased muscle cross-sectional area has been previously shown to be an important determinate of increased muscle strength and may be due to changes in muscle fiber composition (increased percent Type II fibers), muscle fiber area (% area Type II), and pennation angle (Blazevich, Gill, Deans, & Zhou, 2007; Blazevich, Gill, & Shi, 2006; Masuda, Kikuhara, Takahashi, & Yamanaka, 2003). In an investigation examining the effects of different supplementation (combinations of protein, carbohydrate and creatine) in three separate groups of resistance trained males performing the same ten week resistance training regime; Cribb, Williams and Hayes (2007) reported that the group with the largest increase in lean body mass and muscle fiber cross sectional area also experienced the greatest gains in 1RM strength. The authors went on to conclude that at least 40% of the increases in strength could be attributed to hypertrophy of the muscle (Cribb et al., 2007).

Prior to the pre-season training phase, athletes had performed approximately six weeks of off-season training. The off-season training phase consisted of a reduced volume of high intensity training in which athletes complete unsupervised low intensity training in non-specific modalities. Interestingly, 15 of the athletes in the current investigated were assessed for bench press strength in a separate investigation (unpublished findings) at the conclusion of their previous competitive season, immediately prior to the off-season training phase. The investigation used the same methodology for assessing bench press performance. As expected, bench press strength decayed during the off-season at an average rate of 2.2% per week (13.4% over 6 weeks). Previous investigations have also reported detraining effects in elite athletes during an off-season (Caldwell & Peters, 2009; Hãkkinen & Komi, 1985). Hãkkinen and Komi (1985) reported a decrease in squat strength by approximately 10% following a four week off-season in Olympic weight lifters. Additionally, Caldwell and Peters (2009) reported similar detraining findings in semi-professional soccer players. Although no strength measures were assessed, Caldwell and Peters (2009) reported significant decreases in aerobic capacity and lower-body power along with significant increases in 15m sprint time, agility sprint time, and body composition following an off-season training phase. It appears that the increases in strength that occurred in the four week pre-season in the current investigation may essentially be the return to competition levels, which recovered at a slightly quicker rate of approximately 2.7% per week. Therefore, much of the initial increases in strength observed may be due to a reconditioning from the off-season phase. These findings may also suggest that a short term phase of high volume training provides adequate stimulus to recondition previously well trained athletes to competition level.

Power

A small decrease in both upper-body (-5.6%) and lower-body power (-5.2%) occurred over the pre-season. Similar findings were reported by Harris and colleagues (2008), who reported a decrease in peak power following a seven week pre-season in two separate groups of elite rugby league athletes training at either 80% 1RM or the load where peak power was maximised (-17% and -7%, respectively). Harris and colleagues (2008) speculated that decreases in power may have been due to fatigue or decreased effort in the post-training testing occasion. According to the fitness-fatigue model, following a period of stressful training, the magnitude of specific fitness and fatigue after-effects are high (Chiu & Barnes, 2003). A period of training involving reduced total work and relative intensity is required to remove the fatigue after-effects. It is not until the fatigue after-effects have been removed that the training effects can be observed (Chiu & Barnes, 2003). As such, positive training adaptation may have occurred, but was masked by fatigue due to the large volume of training completed accompanied by inadequate recovery prior to testing. The decrease in power observed in the current investigation may be due to several factors including large training volumes and the resultant increase in overall fatigue.

Performing multiple aspects of conditioning during the same phase, as seen in many team sports, may lead to an excess volume of training. Indeed, a large volume of concurrent training was completed over the four weeks of training (53 sessions) in the present study and may have affected power production. It has been previously suggested that high training volume appears to compromise power development (Baker, 2001; Kraemer et al., 1995). In contrast to the findings in the present investigation and that of Harris and colleagues (2008); O’Connor and Crowe (2007) reported a significant increase in lower-body power over a six week pre-season in elite athletes. Notably, these athletes performed only a total of eight sessions each week. The lower volume of total training volume may have minimised fatigue, allowing for appropriate power adaptation to occur (O'Connor & Crowe, 2007).

Athletes in the present investigation reported a moderate increase in fatigue from the start to the end of the training phase. It has previously suggested that power training should be performed with minimal influence from fatigue (Denton & Cronin, 2006). Jurimae and colleagues (2002) reported significant reductions in power output (3.6%) following an increase in training volume and concluded that reductions may have been due to an increased state of fatigue. It therefore appears possible that rugby union athletes, who train with significant loading, may experience some overall fatigue which can result in no improvement and even a small decline in power output.

Body composition

A small increase in fat free mass (2.2 kg) was observed over the training phase in conjunction with a small increase in flexed upper-arm girth (0.6 cm) and a moderate increase in mid-thigh girth (1.9 cm). Additionally, a small decrease in the sum of skinfolds was observed (-11.0 mm). Previous literature has reported significant decreases in sum of skinfolds and increases in fat free mass over a pre-season (O'Connor & Crowe, 2007; Rogerson et al., 2007). It appears that the large volume of training performed in this phase was adequate to elicit positive adaptations in body composition.

Average weekly change

The average weekly rate of change for upper-body and lower-body strength was an increase in 1RM of 3.4 kg and 4.4 kg, respectively. This rate of change is larger than previously reported in similar level athletes over a pre-season training regime of concurrent training. O'Connor and Crowe (2007) and Rogerson et al. (2007) reported an average rate of change of 0.8 kg and 2.7 kg a week for bench press strength, respectively. Interestingly the rate of change was also higher than reported in participants performing single mode training only (resistance training; 1.4 kg and 2.8 kg per week for bench press and squat, respectively) (Cribb et al., 2007). The weekly rate of change for fat free mass was 0.5 kg. This is similar to previously reported changes (0.53 kg weekly increase) in a ten week single mode training regime aimed at increasing muscle strength and size in resistance trained participants (Cribb et al., 2007).

The rate of change findings from the current investigation provide insight for strength and conditioning practitioners who need to know the degree of adaptation that can be made in a short term training phase. These findings show that moderate improvements can be made in strength, fat mass and fat free mass during a short term training phase by performing a high volume of concurrent high intensity aerobic, anaerobic and resistance training. For team sports such as rugby union who perform concurrent training and have regular breaks between campaigns or shorter breaks as seen during a bye week or rest week, positive gains can be made quickly to allow athletes to further develop or to allow for a reconditioning to occur.

Conclusions

Increases in strength and fat free mass can be achieved in a relatively short time during a high volume short term training phase consisting of concurrent training in elite/professional athletes. Although a single resistance training session per week may maintain or improve these variables; performing a greater volume of resistance training sessions per week may elicit greater performance benefits. However, as some loss of power production may occur with such high training volumes, specific training phases involving a lower volume work and less cumulative fatigue may be required closer to competition if improvements in power are to occur. This may be potentially achieved during the pre-competition phase where content of training becomes more focused on skill and game plans rather overall than conditioning.

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Table 1. Outline of the final training week during the pre-season training phase in professional rugby union athletes.

	Monday	Tuesday	Wednesday	Thursday	Friday
AM	Speed + Resistance Training	Resistance Training + Aerobic/Anaerobic Conditioning	Aerobic/Anaerobic Conditioning	Resistance Training	Resistance Training + Team Training

PM	Boxing + Team Training	Resistance Training	Aerobic/Anaerobic Conditioning	Team Training + Aerobic/Anaerobic Conditioning	Boxing + Recovery

Resistance Training: Typical exercises were: squat variation, vertical push, vertical pull, horizontal press.

Team Training: Defense, attack, game plan and general skills.

Anaerobic Conditioning: Repeated high intensity running efforts e.g. 10x 20m @ 20s, 10x 50m @ 40s.

Aerobic Conditioning: Low-moderate running/cycling/swimming/rowing efforts of 20-40 min.

Speed: Agility drills for 5-10min, resisted sprints 10-20m x 4-8 reps, overspeed bungees 20m x 2-3 reps, 20-50m sprints x 2-3 reps.

Recovery: 20min light cycling, 10 min Contrast Baths and 30 min massage.

Boxing: Repeated high intensity punching, 1:1 work:rest, 10x10s, 10x20s 8x30s, 5x1min, 3x2min.

Table 2. Training mode, training frequency, and ratings of perceived exertion in elite rugby union athletes over a four week pre-season training phase

Training Mode	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Total Sessions**	**Mean RPE**
Resistance Training	3	5	7	5	**20**	7.1
Hill Sprints	2	1	1	0	**4**	9
Boxing training	2	2	1	2	**7**	8.4
Aerobic and anaerobic conditioning	2	5	5	4	**16**	7.4
Speed	0	0	2	1	**3**	6.9
Rugby Specific Training	0	0	0	3	**3**	5.6
Total Sessions	**9**	**13**	**16**	**15**	**53 (Total)**	**7.4 (Mean)**

RPE, ratings of perceived exertion.

Table 3. Baseline values and change in strength, power and body composition, and fatigue in elite rugby union athletes over a four week pre-season training phase.

Measure	Pre Value (± SD)	Post Value (± SD)	Change (± 90 % CL)	Meaning-fulness	Weekly Change
Bench Press (kg)	124.3 (± 19.1)	137.9 (± 20.0)	11.1% (±2.3%)	Moderate	2.7%
Box Squat (kg)	154.8 (± 25.7)	172.4 (± 30.7)	11.3% (±4.7%)	Moderate	2.8%
Bench Throw (W)	1158.2 (± 210.8)	1087.6 (± 177.0)	-5.6% (±5.1%)	Small	-1.5%
Jump Squat (W)	5359.8 (± 626.9)	5079.6 (± 547.4)	-5.2% (±4.6%)	Small	-1.3%
Sum of 8 Skinfolds (mm)	93.4 (± 26.7)	82.4 (± 22.5)	-11.5% (±2.6%)	Small	-3.0%
Fat Mass (kg)	13.7 (± 4.8)	12.3 (± 4.1)	-9.5% (±2.8%)	Small	-3.3%
Fat Free Mass (kg)	86.8 (± 7.2)	91.1 (± 7.8)	2.2% (±0.6%)	Small	0.7%
Upper-arm Girth (cm)	39.0 (± 2.0)	39.6 (± 1.9)	1.6% (±0.5%)	Small	0.4%
Chest Girth (cm)	109.4 (± 6.5)	109.9 (± 5.7)	0.5% (±0.9%)	Trivial	0.1%
Mid-thigh Girth (cm)	55.5 (± 2.7)	57.4 (± 3.0)	3.5% (±0.9%)	Moderate	0.9%
Fatigue (units)	1.8 (± 0.9)	2.4 (± 0.8)	0.6 (±0.4)	Moderate	0.2

CL, confidence limits.