The Effects of Augmented Feedback on Sprint, Jump, and Strength Adaptations in Rugby Union Players Following a Four Week Training Programme.

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ABSTRACT

Purpose*:* Feedback can enhance acute physical performance. However, the effects of feedback on physical adaptation has received little attention. Therefore, the purpose of this study was to determine the effect of feedback during a four-week training programme on jump, sprint and strength adaptations.

Methods: Twenty-eight semi-professional male rugby union players were strength-matched into two groups (feedback and non-feedback). During the four-week training programme, the Feedback group received immediate, objective feedback on a) mean concentric velocity during resistance training repetitions, b) distance feedback for standing broad jumps, and c) time for sprints. The Non-Feedback group were not provided additional information. Across the four-week mesocycle, subjects completed three strength and conditioning sessions per week. Countermovement jump (CMJ), standing long jump, 10 and 20m sprint, and three repetition maximum (3RM) barbell back squat and bench press were measured pre- and post- the training intervention. Magnitude-based inferences assessed meaningful changes within- and between-groups.

Results*:* The Feedback group showed *small* to *moderate* improvements in outcome measures, while the Non-Feedback group demonstrated *trivial* to *small* improvements. Improvements in CMJ relative peak power (effect size ±90% confidence limits: 0.34±0.42), 10m (0.20±0.35) and 20m sprint (0.40±0.21), and 3RM back squat (0.23±0.17) were *possibly* to likely greater for the Feedback condition compared to Non-Feedback.

Conclusions*:* Results indicate that providing augmented feedback during strength and conditioning routines can enhance training adaptations when compared to athletes who do not receive feedback. Consequently, practitioners should consider providing kinematic outputs, displacement, or sprint time at the completion of each repetition as athletes train.

Key Words: Augmented Feedback; Strength; Speed; Countermovement Jump

INTRODUCTION

Athletes participating in sport are typically exposed to strength and conditioning programmes[1-3]. In particular, strength and conditioning interventions often incorporate resistance training and plyometrics (e.g. jump training) which are both safe and effective for the development of strength and power[4]. Strength and conditioning programmes are developed by manipulating numerous acute variables (e.g. load, volume of sets and repetitions, exercise type, repetition velocity), which alter the physiological stimulus and subsequent adaptation[5]. While practitioners and researchers often focus upon *what* is included within a training programme, less consideration is given to *how* training programmes are delivered[6]. This may be just as important, given external variables such as the provision of augmented visual and verbal kinematic feedback (e.g. mean concentric velocity) when exercising have been found to enhance acute training performance and physical development[2,7,8].

By providing kinematic feedback to athletes as they train, acute improvements in jump squat[9], bench press throw[7], and barbell back squat[2] performance have been shown to occur. For example, Argus et al.[7] demonstrated the effects of verbal kinematic feedback (i.e. peak concentric velocity) on professional rugby union players with mean improvements of up to 3.1% in the bench press throw. Additionally, Weakley et al.[2] demonstrated clear and substantial improvements of 7.6% in mean concentric velocity during the barbell back squat when adolescent rugby union players were provided visual kinematic feedback of mean concentric velocity. Furthermore, these improvements were found to occur alongside increases in motivation and competitiveness[2].

Due to the importance of velocity and power output when exercising[10,11], the ability for augmented feedback to enhance physical adaptations have shown promise[8,9,11]. Nagata et al.[9] demonstrated large improvements (effect size (ES): 1.25) in jump squat velocity for subjects who were provided immediate verbal feedback of barbell velocity following each training repetition of the jump squat across a four week training period when compared to individuals who did not receive feedback. Furthermore, Randell et al.[8] demonstrated that visual kinematic feedback following each repetition of the barbell jump squat throughout a six week training routine can elicit *possible* and *likely* improvements in 20m sprint (ES: 0.20) and horizontal jump (ES: 0.28) performance, respectively. However, these training studies have only provided feedback following the jump squat exercise, with no research to date having implemented feedback across all exercises within a strength and conditioning programme.

To this end, the aim of our study was to assess the effects of providing feedback across all exercise components within a four-week training programme on jump, sprint and strength measures in rugby union athletes.

METHODS

Subjects

Twenty-eight semi-professional, male, rugby union players (Feedback: 16 subjects; Non-Feedback: 12 subjects) completed the training and testing protocols (mean ± SD; Feedback age: 21 ± 1 yrs; Non-Feedback age: 21 ± 2 yrs; Feedback group height: 185.9 ± 6.2 cm; Non-Feedback height: 183.4 ± 5.8 cm; Feedback body mass: 98.4 ± 13.1 kg; Non-Feedback body mass: 93.6 ± 8.5 kg). Thirty-one players were initially recruited to take part in the study but three subjects were not included in the final analysis as they did not attend >90% of the strength and conditioning sessions. All subjects had at least two years of resistance training experience[12] and were recruited from a British University and Colleges Super (BUCS) Rugby squad in the United Kingdom. The training and testing took place from August until October (which is during the pre-season period of the BUCS playing calendar). All subjects confirmed that they did not have any current injuries, do not consume any medications or supplements that could influence performance and adaptations, and were not suffering from any diseases. Prior to the study, all subjects had completed a six-week standardised preparatory phase where all resistance training exercises and intensities were specified. Subjects were explained the design of the study, were provided an opportunity to ask questions and then provided informed written consent. All experimental procedures were approved by Leeds Beckett University's ethics committee in accordance with the Declaration of Helsinki, and written assent was provided by all subjects.

Experimental Design

Our study is a pre-post, quasi-experimental, randomised controlled trial that assessed the effects of providing feedback during a four-week training mesocycle on jump, sprint and strength measures in 28 players who were strength-matched and allocated into either a feedback (Feedback) or non-feedback (Non-Feedback) training group (A-B-B-A distribution). All subjects took part in the same three strength and conditioning sessions per week throughout the study, with each session including plyometric and resistance training exercises, and sprint accelerations. Subjects within the Feedback group were provided augmented feedback of performance with mean concentric velocity provided for the resistance training repetitions, displacement feedback for each broad jump, and time to completion feedback after every training sprint, while the Non-Feedback group did not receive any form of augmented feedback. Pre- and post- the training mesocycle, all participants completed a body weight CMJ upon a force plate, a standing broad jump, a 20m linear sprint, and a three repetition maximum (3RM) back squat and bench press.

Procedures

Preceding the initial testing session, all subjects were provided 72 hours active rest and were required to complete a standardised warm up followed by 1) an unloaded CMJ upon a force platform (NMP Technologies Ltd., ForceDecks Model FD4000a, London, UK); 2) a standing broad jump; 3) a 20m linear sprint; 4) a 3RM bench press and barbell back squat. Subjects were then strength matched (using maximal back squat strength) and randomly assigned into one of two groups (i.e. Feedback or Non-Feedback). During the following four weeks all subjects completed at least 90% of gym sessions (i.e. three resistance training sessions per week; refer to Table 1 for resistance training sessions) and field training sessions (three sessions per week) with one group (i.e. Feedback) receiving feedback following each repetition of each multi-joint barbell exercise. The Non-Feedback group did not receive augmented feedback but were required to use maximal intent with each repetition of each exercise. Feedback was supplied through the use of linear position transducers, measuring tapes, and speed gates. In addition, no verbal encouragement was provided for either training group. At the end of the four-week mesocycle and 48 hours after the final training session, subjects completed the same testing battery that was completed prior to the training mesocycle.

Countermovement jump

The CMJ was completed pre- and post- the training mesocycle using a force platform which sampled at a rate of 1,000 Hz. Three CMJs were completed by all players, with feet placed shoulder width apart and with hands placed on hips[13,14]. Participants lowered themselves to a self-selected depth and jumped as high as possible. Between each maximal effort, 60 seconds rest was provided[13,14]. Variables which were included in the analysis were CMJ height and relative peak power (PP/BM). These variables were selected based on previously published between-day reliability statistics in a similar cohort[13] and their close relationship with physical performance[15] and use in rugby union players[14,16,17].

Standing Broad Jump

Standing broad jump methodology followed the same protocols previously outlined by Randell et al.[8]. Briefly, subjects stood with feet shoulder width apart and toes placed on a line on the ground. Subjects then performed a forward countermovement horizontal jump, which allowed arm swing, along the length of a tape measure that was secured to the ground. Subjects were required to "stick the landing", with no additional foot movement allowed upon landing. Distance jumped was calculated as the distance from the jump initiation line to the heel of the back foot. The best of three attempts was recorded, with 60 seconds recovery provided between attempts. All distances were measured to the nearest 0.01 metre.

10 and 20m sprints

Following a standardised dynamic warm-up, subjects had two attempts at a 20m maximal linear sprint, with times being recorded at 10 and 20m using timing gates (Brower Timing Systems; IR EMIT, USA). Individuals were required to start with their foot 0.05m behind the timing gates, with timing self-initiated during the passing of the first gate. Testing took place on the same track pre- and post- study with each subject being provided two attempts with three minutes provided between repetitions[18]. The fastest of the two repetitions was selected and used for analysis. All times were measured to the nearest 0.01 second[18].

3RM Strength Assessment

Assessment of the 3RM back squat and bench press were chosen as these tests of strength are commonly completed in rugby union players of a similar standard[14,19,20]. Additionally, all subjects within this cohort were familiar with the 3RM testing protocols. Subjects first completed a dynamic warm up which has previously been completed prior to maximal 3RM attempts [14,20]. Maximal back squat strength was completed with a barbell (Eleiko Sport AB, Halmstand, Sweden) resting on the upper trapezius with participants grasping the bar with a pronated grip. Subjects were then required to lower themselves so that the top of the knee was parallel with the fold between the torso and thigh (observed by the lead researcher). Heels were to remain in contact with the ground throughout the movement, and the participant was to return to the initial standing position. The 3RM bench press required subjects to select a comfortable grip on the barbell (Eleiko Sport AB, Halmstand, Sweden) and were required to lower the bar to touch the chest and return to the starting point with the arms fully extended without any assistance.

Strength and conditioning routine

Table 1 outlines the strength and conditioning training protocols that all subjects undertook across the four-week mesocycle. The resistance training exercises and sessions prescribed were part of the regular preseason routine and were based upon previous research[8,21]. There were two different training routines (session one and session two) and these were completed in an alternating order so that each individual session was completed six times. At the beginning of each session a dynamic warm up was completed with individuals then completing all exercises in the prescribed order. Players were only provided objective values following each repetition and did not receive additional feedback of performance (i.e., indications of good or bad outcomes).

Resistance training exercises

Across the training mesocycle, subjects within the Feedback group were provided feedback of mean concentric velocity following each repetition during all multi-joint barbell resistance exercises. All repetitions of resistance training exercises were recorded with a GymAware linear position transducer (Kinetic Performance Technology, Canberra, Australia) which sampled at 50Hz. The optical encoder, which was placed directly below the barbell during all movements, contains a retractable cord that attaches to the barbell during each set for each subject. Velocity is calculated from the measurement of displacement and time, with the calculation of velocity previously being demonstrated to be valid[22]. This velocity information is transmitted to an iPad (iPad Pro, Apple Inc., Cupertino, California, USA) which can be relayed to the subject either visually (hexagonal bar deadlift and jump squat, barbell back squat, and bentover row)[2,23] or verbally (jump squat and bench press)[7]. During auxiliary exercises (e.g. Nordic drops and front planks), augmented feedback was not provided.

Sprint and broad jump

Subjects within the Feedback group had all distances and times in the standing broad jump and 15m sprint accelerations provided after each repetition, respectively. Subjects within the Non-Feedback group did not receive augmented feedback but were required to complete each repetition with maximal intent. During the standing broad jump, jumps were completed using the methodology outlined above with distances being provided after each repetition. During the 15m accelerations, timing gates were set up on an indoor track and times were provided to each individual at the end of each repetition.

Insert Table 1 here

Statistical analysis

Data are presented as either mean ± SD or ES ± 90% confidence limits (90%CL) where specified. Prior to analysis, all data were log-transformed to reduce bias arising from non-uniformity error, and then analysed for practical significance using magnitude-based inferences[24]. Within-group changes and between-group differences in these changes were analysed using an online spreadsheet[25]. Changes and differences were adjusted to the mean baseline of each outcome measure, with the threshold for a substantial effect being specified as 0.2 multiplied by the pooled between-player baseline SD in each outcome measure. The probability that the magnitude of the effect was greater than these thresholds was rated as <0.5%, *almost certainly not*; 0.5-5%, *very unlikely*; 5-25%, *unlikely*; 25-75%, possibly; 75-95%, *likely*; 95-99.5%, *very likely*; >99.5%, *almost certainly*[26]. Where the 90%CL crossed both the upper and lower boundaries of the SWC (ES±0.2), the magnitude of change was described as *unclear*[26]. ES thresholds were set at <0.2 (*trivial)*, 0.2-0.59 (*small*), 0.6-1.19 (*moderate)*, and 1.2-2.0 (*large*)[26].

Results

All baseline between-group differences were unclear. Additionally, attendance was 98% for both the Feedback and Non-Feedback groups.

Table 2 presents the changes in physical performance from pre to post testing and corresponding ES ± 90%CL and inference. Figure 1 presents the within group ES ± 90%CL and between group ES ± 90%CL and corresponding inference.

Insert Table 2 here

Insert Figure 1 here

DISCUSSION

The aim of our study was to assess the effects of providing feedback during a four-week training mesocycle on jump, sprint, and strength adaptations. After the four weeks, possible to clear and substantial improvements in physical performance occurred in the Feedback group, while the Non-Feedback group showed almost certainly trivial to very likely improvements. Additionally, the Feedback group showed possibly to likely greater improvements in PP/BM, 10 and 20m sprint time, and the 3RM back squat when compared to the Non-Feedback. Our findings highlight the importance of providing feedback when implementing strength and conditioning routines and suggest that training adaptations may be superior when augmented feedback is provided even across a 4 week period. Therefore, when feasible, practitioners should consider implementing methods of objective feedback (e.g. through the use of linear position transducers, timing gates, and measuring tapes) when planning and delivering strength and conditioning training programmes.

Between group differences demonstrated possibly beneficial improvements in PP/BB (0.20 ± 0.33) with likely trivial differences observed in CMJ height (0.14 ± 0.26). This partly corroborates with previous research that has shown that when athletes are provided frequent feedback of jump performance across a training mesocycle (i.e. 4-6 weeks), changes in jump performance can occur[8,9]. The provision of feedback can cause immediate enhancements in jump height, with these acute improvements providing a greater stimulus and promoting superior adaptations[11], but these adaptations may be more prominent in relative peak power output. While previous research has suggested that frequent feedback of performance may cause dependency[27], recent research by Keller et al.[11] has shown that, in movements that are familiar (e.g. jump squats), a high frequency of feedback can augment improvements compared to infrequent or no feedback. This is supported by Nagata et al.[9] who has shown that jump performance is improved to a greater extent when feedback of barbell velocity is supplied following each repetition compared to the average velocity of the entire set. Consequently, it is suggested that in exercises that athletes are familiar with, augmented feedback is supplied with a high level of regularity (e.g. following each repetition). This may lead to greater improvements in relative peak power.

Though small, possibly beneficial improvements in CMJ height performance were observed in the Feedback group, unclear (ES±90%CL: 0.10 ± 0.30) differences were seen between groups in the horizontal broad jump. Porter et al.[28] has previously demonstrated the benefit of an externalised focus of attention on acute horizontal jump performance, yet within our study, these acute enhancements did not transpire as adaptations in jumping ability. It is thought that this uncertainty in between group differences may stem from subjects being able to visually observe the distance that they jumped regardless of whether a tape measure was provided. This is unique to the broad jump as other exercises rely on information supplied through technology (i.e. linear position transducers and timing gates). Additionally, due to the highly technical element of this test, between group differences may have been obscured.

Small, possible and likely greater improvements in 10 and 20m sprint performance occurred, respectively, when feedback was supplied. These improvements are consistent with research by Randell et al.[8], and supports the tenet that augmented feedback can enhance sprint ability.

However, the current study is the first to include and investigate the effects of feedback following sprint repetitions. Previous research has shown that feedback can enhance competitiveness and motivation[2], with these psychological traits being linked to improved physical performance[23]. Indeed, it was evident throughout the study that subjects within the Feedback group frequently compared their sprint times and actively competed amongst each other. This accumulation of increased stimulus may have facilitated the augmented adaptations that were prevalent at 10 and 20m. Thus, the inclusion of timing gates throughout a training mesocycle may be a simple method of enhancing accelerative sprint ability.

Our study is also the first to investigate strength adaptations when athletes are provided feedback. Possibly greater improvements were observed in the 3RM squat, while trivial differences were observed in the bench press in the Feedback group. These results suggest that feedback of performance while training may have greater benefit for the lower body when compared to the upper body. Previous research has investigated the effects of providing kinematic feedback on the back squat exercise and demonstrated that clear substantial improvements in barbell velocity occur with its provision[2,23]. These improvements in performance have been attributed to enhanced motivation and competitiveness[2,23], and individuals feeling that an active interest in their training is occurring[29]. This greater improvement in lower body strength may have facilitated the possibly greater development in CMJ PP/BM and 10 and 20m sprint time that were observed. Consequently, individuals hoping to maximise strength development in the lower body may benefit from the provision of kinematic information when completing resistance training.

While our study is the first to assess the physical adaptations of training with or without feedback following each repetition across a range of exercises and movements, it is not without limitations. First, potential differences in on-field training between groups were unable to be accounted for. While all subjects that were included in this study were from the same squad of rugby players and took part in the exact same training exercises, slight differences in rugby training loads cannot be dismissed. To counter this, all playing positions were included within the study (with both forwards and backs in each group) and individuals were matched for lower body strength prior to randomisation. Second, due to the difficulties associated with ecologically valid training studies, the training mesocycle that was completed was only four weeks. While longer exposure to these different methods of training may have caused greater differences between groups, previous research investigating the effects of feedback on physical adaptations have shown substantial improvements across similar lengths of time (i.e. 4-6 weeks) with less frequent training[8,9,11]. Consequently, it was decided that a four-week period was an appropriate length of time to establish differing training adaptations. Finally, it is important to acknowledge that while improvements in physical characteristics in the Feedback group were possibly greater, the influence of these changes on playing performance is still unknown. Therefore, these findings should not be extrapolated to immediate improvements in on-field outcomes.

CONCLUSIONS

In conclusion, the findings from our study suggest that the provision of frequent, augmented feedback throughout a strength and conditioning programme can enable enhanced physical adaptations to training. These adaptations may be due to increases in training stimulus that subjects experience (i.e. greater acute kinetic and kinematic outputs)[2,7] and enhanced motivation and competitiveness[2,23]. Augmented feedback can be provided through a range of methods (including linear position transducers, timing gates, and tape measures) and practitioners should consider tailoring methods of feedback to fit within their own individual training programmes. The means of feedback within this study were time-efficient, highly practical, and could be utilised within a range of training environments. Further research may wish to investigate the effects of feedback over prolonged periods of times, and the effects of different kinetic and kinematic variables used to provide feedback. However, the findings of the present study demonstrate that the inclusion of feedback methods whilst training can be of benefit as an accompaniment to the strength and conditioning professional.

PRACTICAL APPLICATIONS

The use of augmented feedback during training can enhance physical adaptations and has previously been shown to improve motivation and competitiveness. Feedback can be provided in a variety of ways that can be adapted to individual strength and conditioning routines and can be selectively applied during specific exercises. It is suggested that practitioners provide mean or peak concentric velocity during resistance training movements, time during sprint or acceleration drills, and displacement during plyometric movements. This instantaneous feedback could be through the use of valid velocity measuring devices (e.g. linear position transducers), timing gates, and measuring tapes. Providing feedback verbally and/or visually can be beneficial, and by strategically selecting feedback methods, practitioners may be able to spend increased time working with athletes who require greater support. However, the cost of some technology or feedback methods may be prohibitive. Therefore, due to the possibly and likely small improvements demonstrated across this four-week period, the practitioner should consider the relative cost and benefits associated with implementing this technology.

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