Show me, Tell me, Encourage me: The Effect of Different Forms of Feedback on Resistance Training Performance.

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ABSTRACT

When performing resistance training, verbal and visual kinematic feedback are known to enhance performance. Additionally, providing verbal encouragement can assist in the attenuation of fatigue. However, the effects of these forms of feedback have never been compared. Consequently, this study aimed to quantify the effects of verbal and visual kinematic feedback, and verbal encouragement on barbell velocity during the back squat. Furthermore, changes in performance were related to individual reported conscientiousness. Twelve semi-professional rugby union players volunteered to participate in the study which consisted of the subjects completing a set of the barbell back squat across four conditions (i.e. no-feedback (control), verbal feedback of kinematic information (verbal), visual feedback of kinematic information (visual), and verbal encouragement (encouragement)). Additionally, participants completed a questionnaire prior to the study to assess conscientiousness. Magnitude-based inferences were used to assess differences between conditions, while Spearman's rank correlation coefficient was used to assess relationships between conscientiousness and changes in barbell velocity. All three forms of feedback showed *almost certain* improvements in barbell velocity, while differences between interventions were *likely* to *very likely trivial*. Changes in barbell velocity showed *small* to *large* inverse relationships with conscientiousness. These findings suggest that practitioners should supply kinematic feedback (verbally or visually) or, when technology is not available, provide athletes with encouraging statements while resistance training. Verbal encouragement may be of greatest benefit for individuals who demonstrate low levels of conscientiousness. Given these findings, practitioners are advised to use either technology or verbal encouragement to manipulate acute training outcomes.

Key Words: Verbal encouragement; Visual feedback; Verbal feedback; Conscientiousness, Velocity, Velocity-based training

INTRODUCTION

Resistance training can improve lean body mass, strength, and power (16, 21). Additionally, it is known to augment physical performance (e.g. jump height) which may be of benefit for sporting outcomes (10). To promote these positive adaptations, resistance training needs to be of a high quality that involves athletes producing high kinematic outputs (e.g. power and velocity) (16). However, athletes do not always complete training that maximises these outputs. This may be because of physiological (e.g. neuromuscular fatigue) (19, 25) or psychological mechanisms (e.g. low motivation or conscientiousness) (26, 27). Therefore, finding methods that enhance these traits may be of benefit for coaches and athletes.

One method that has been shown to promote greater kinematic outputs when resistance training has been the delivery of instantaneous kinematic feedback following each repetition (2, 26). Weakley et al. (26) has shown that adolescent rugby union players who are provided visual kinematic feedback when completing the back squat have *almost certain* improvements in mean concentric velocity (percentage difference ±90% confidence intervals (90%CI): 7.6 ± 3.6) (26). Additionally, professional rugby union players when verbally provided kinematic information, have shown improvements of 1.3% (±0.7) in peak velocity across multiple sets in the bench press throw (2). These improvements are speculated to occur as a result of externalised focus promoting improvements in motor unit efficiency (28, 29) and greater effort as athletes feel there is an active interest taking place in their training (14). Additionally, these improvements in acute performance have been demonstrated to enhance physical adaptations (e.g. jump performance) in rugby league players (18). However, the provision of kinematic feedback to athletes can require technology that is cost prohibitive to many practitioners.

Alternatively, providing verbal encouragement can be a cost-effective method of enhancing resistance training performance (15). Previous research has shown that physical adaptations and training adherence are greater when a strength and conditioning practitioner is present (20). Additionally, McNair and colleagues (15) have demonstrated that acute improvements in peak force occur (effect size (ES): 0.67) during isokinetic exercise when verbal encouragement is delivered to participants. However, this has been challenged by Campenella et al. (7) who found that peak torque of the quadriceps and hamstrings is unchanged with verbal encouragement. Differences between these findings were thought to be due to the frequency with which encouragement is provided (7) with previous research suggesting that frequent motivating statements (e.g. "come on!") is beneficial for performance (1). Consequently, it is suggested that verbal encouragement is regular and consistent through bouts of high-intensity exercise (1). By providing this support, it is thought that athletes are more motivated to perform and subsequent performance can be enhanced.

Recent investigations have acknowledged that multi-disciplinary research can be of benefit for athletic development (26, 27). Specific personality traits, such as conscientiousness (i.e. behaviour that is "responsible, dependable, persistent, and achievement-orientated" (4)), are known to influence physical performance when performing tests of maximal effort (6). Recently it has been established that, when verbally encouraged, individuals with lower levels of conscientiousness show large improvements in maximal voluntary contraction (9.27%; $p <$

0.05) when compared with individuals with greater conscientiousness (6). It has been speculated that by identifying individuals of various levels of conscientiousness feedback methods can be tailored for that individual. However, despite the importance of this personality trait on physical performance (6, 8), its investigation in sports science has been rare. Consequently, the relationship between conscientiousness and various forms of feedback should be further explored.

Several forms of kinematic feedback and verbal encouragement have been investigated and found to have positive effects on resistance training performance (2, 15, 26). This research has particularly focussed on semi- and professional rugby players (2, 18, 26). Additionally, feedback has been shown to affect muscular performance to varying degrees in individuals of differing conscientiousness (6). However, only recently have these claims begun to be explored, with the optimal type of feedback for resistance training not yet known (26, 27). Consequently, the aim of this study was to assess the effects of verbal and visual kinematic feedback, and verbal encouragement on resistance training performance in semi-professional rugby union players. In addition, relationships between conscientiousness and changes in kinematic outputs were also examined. Based upon previous findings (2, 6, 26), it is hypothesised that all forms of feedback will enhance kinematic outputs, and that relationships between changes in barbell velocity and conscientiousness will be observed.

METHODS

Experimental Approach to the Problem

Before the first testing occasion, 12 semi-professional rugby union players were required to complete a questionnaire which assessed conscientiousness. Subjects then performed a set of 10 repetitions with no feedback (i.e. control), verbal kinematic feedback, visual kinematic feedback, and verbal encouragement in a randomised crossover design. Each condition (control, verbal kinematic, visual kinematic, and verbal encouragement) was separated by three to four days. Differences in average barbell concentric velocity during each feedback condition (compared to control) were then related to reported levels of conscientiousness.

Subjects

A convenience sample of twelve male semi-professional rugby union players (mean ± SD; age: 21.8 ± 0.9 yrs; height: 1.83 ± 0.08 cm; body mass: 94.2 ± 8.7 kg; three repetition maximum (3RM) back squat: 142.9 ± 19.4 kg) from a British Colleges and University rugby union team in the United Kingdom volunteered to participate in this study. Testing took place in the last week of July and first two weeks of August (which is at the start of the British Universities and Colleges Super Rugby pre-season). All subjects had completed a standardised off-season training programme for the previous eight weeks, and had at least two years resistance training experience (23). All subjects were informed of the risks and benefits of this study and signed a consent document prior to commencement. Prior to approaching potential subjects, all experimental procedures were approved by the Leeds Beckett University ethics committee.

Experimental Procedures

All testing was conducted during the rugby union pre-season (i.e. July-August), at the same time of day (0900 - 0945 hours), three to four days apart (i.e. Monday and Thursday), with at least 48 hours active rest prior to testing procedures. Subjects were instructed to maintain normal dietary habits in the 24 hours prior to all testing, with caffeine not being consumed in the 12 hours before. All subjects completed a familiarisation and testing session that included anthropometric and 3RM back squat strength assessments. All four conditions were then completed in a randomised crossover order which was decided through computer-generated random numbering. All sessions consisted of a standardised warm-up and one set of 10 repetitions of the back squat at 75% of 3RM. This intensity and repetition scheme were selected as they have previously been used to assess the effects of visual kinematic feedback on resistance training performance (26, 27). The verbal kinematic feedback condition consisted of the lead researcher standing perpendicular to the subject and verbally stating the mean concentric barbell velocity (which was recorded on an iPad (iPad Pro, Apple Inc., Cupertino, California, USA)) at a volume slightly greater than conversation volume (2). The visual kinematic feedback condition consisted of the subject completing 10 repetitions with an iPad (placed approximately one metre away) displaying mean concentric velocity ($m \cdot s^{-1}$) directly in front of them at standing eye level (26, 27). The verbal encouragement condition consisted of the lead researcher standing perpendicular to the subject and supplying standardized verbally encouraging statements during repetitions two to nine (i.e. repetition two: “Way to go!”; repetition three: “Come on!”; repetition four: “Good job!”; repetition five: “Excellent!”; repetition six: “Come on, push it!”; repetition seven: “Keep it up!”; repetition eight: “Push it!”; and repetition nine: “Let’s go!”). These phrases were chosen as they have previously been shown to improve physical performance (1). All verbal encouragement was at a volume slightly louder than normal conversation volume. This was to offset the noise that occurs within a gymnasium and has previously been used by Argus et al. (2). Finally, the control condition consisted of the subjects completing all 10 repetitions without any type of feedback or encouragement. Mean concentric velocity was recorded via the back squat in each condition using a linear position transducer due to its common use in resistance training programmes and use as a monitoring tool (3, 26).

Lower-body Strength Assessment

One week prior to the initiation of testing the effects of feedback and verbal encouragement on performance, the 3RM back squat was assessed using the same protocol that has been used in other semi-professional rugby union players (22, 25). With the bar resting upon the upper trapezius, subjects lowered themselves so that the top of the knee was parallel with the fold between the torso and thigh; visually monitored by the lead researcher. The heels were to remain in contact with the floor, while the torso was to remain upright. The eccentric portion of the squat was two seconds, with a one second pause at the bottom of the movement. The concentric portion of the exercise was instructed to be as "forceful and powerful" as possible (24). On completion of the maximal strength testing, 75% of each subject's 3RM back squat was calculated.

Assessment of conscientiousness

On the same day as the maximal 3RM back squat testing but before any physical exercise was completed, a short form of the Five Factor Personality Inventory (FFPI) was employed to assess individual levels of conscientiousness (17). To isolate conscientiousness within this study, only the conscientiousness subscale was utilised. Previous research from Binboga, et al. (6) have used similar methodology to assess this trait in sports science. Internal consistency coefficients for the conscientiousness personality trait has reported satisfactory levels at 0.77 (17).

Experimental Trials

Following a standardised warm up that involved dynamic movements and stretches, all subjects completed a single set of the back squat at 75% of 3RM. All repetitions in each condition were required to be completed in the same manner as the lower-body strength assessment, with the concentric phase again instructed to be as “forceful and powerful” as possible. Mean concentric velocity was obtained from a GymAware (Kinetic Performance Technology, Canberra, Australia) linear position transducer which sampled at 50Hz. The numerical value of each repetition’s velocity was calculated and transmitted to an iPad and provided either verbally or visually to the participant. During the verbal encouragement condition, the encouraging statement for each specific repetition (refer to Experimental Procedures) was provided at the beginning of the concentric portion of repetitions two to nine (1). These were standardized across subjects for timing, content, and frequency. Finally, when completing the control condition subjects did not receive feedback or any verbal encouragement.

Statistical Analyses

Data are presented as mean ± SD, mean ± 90%CI, or as Spearman’s rank correlation coefficient. Prior to analysis, kinematic data that was used to assess differences between feedback conditions were log-transformed to reduce bias arising from non-uniformity error, and then analysed for practical significance using magnitude-based inferences (11). The chance of the mean concentric velocity being lower, similar, or greater than the smallest worthwhile difference (i.e. 0.2 x between participant difference) was calculated using an online spreadsheet (13). Between condition differences were then further assessed using an additional spreadsheet (12). The probability that the magnitude of the change was greater than the smallest worthwhile change 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* (11). Differences less than the smallest worthwhile change were described as *trivial*. In cases where the 90% CI crossed the lower and upper boundary of the smallest worthwhile change, the magnitude of the difference was described as *unclear (22)*. ES thresholds were set at <0.2 (*trivial)*, 0.2-0.6 (*small*), 0.6-1.2 (*large)*, and 1.2-2.0 (*very large*) (11). These thresholds were selected as they have previously been used to describe changes in kinematic outputs when resistance training in manuscripts relating to visual and verbal feedback (2, 18, 26). Spearman's rank correlation coefficient was used to assess relationships between change scores (i.e. differences in set mean concentric velocity between control and intervention conditions) and subject conscientiousness scores. This was due to the relatively small sample size and poor distribution of the conscientiousness scores. Descriptor thresholds were set at; 0.0-0.1 (*trivial*) 0.11-0.3 (*small*), 0.31-0.49 (*moderate*), 0.50-0.69 (*large*), 0.71-0.9 (*very large*), and 0.91-1 (*nearly perfect*) (5).

RESULTS

Figure one shows the mean concentric velocity ($m \cdot s^{-1}$) of each repetition during the four conditions. Additionally, average concentric velocity (mean ± SD) of the entire set (i.e. control (0.61 ± 0.04), verbal (0.64 ± 0.03) and visual (0.64 ± 0.04) kinematic, and verbal encouragement (0.64 ± 0.04)) conditions are reported. *Almost certainly* greater (ES±90%CI) average mean concentric velocity across the ten repetitions were found when verbal (0.86 ± 0.21) and visual (0.77 ± 0.19) kinematic feedback, and verbal encouragement (0.74 ± 0.22) were compared with the control condition. Table one shows the ES (±90%CI) and inference of each repetition when compared to the control. Between the three feedback conditions, *trivial* or *unclear* outcomes were found across all repetitions apart from number 10. During the final repetition s*mall, possible* to *likely* increases in mean concentric velocity were observed in the verbal kinematic condition when compared to the visual kinematic (0.25 ± 0.43) and the verbal encouragement (0.37 ± 0.42) conditions, respectively.

Insert figure 1 here

Insert table 1 here

Conscientiousness was found to have *small* and *moderate* inverse relationships with the provision of verbal kinematic feedback (r = -0.24) and visual kinematic feedback (r = -0.44), respectively. However, levels of conscientiousness were found to have *large* inverse relationship with change scores in the verbal encouragement (r = -0.52) condition.

DISCUSSION

The aim of this study was to assess the effects of different forms of kinematic feedback and verbal encouragement on resistance training performance in semi-professional rugby union players. Furthermore, this study assessed the relationship between conscientiousness and changes in barbell velocity when provided kinematic feedback or verbal encouragement. The primary findings from this study showed that *moderate* improvements in barbell concentric velocity occur when feedback or encouragement is supplied. Furthermore, there are *possible* to *likely trivial* differences between the different forms of feedback and encouragement. Additionally, it was found that conscientiousness had *large* inverse relationships with improvements in average set concentric velocity when subjects were supplied verbal encouragement. This study highlights the complex link between physical performance and conscientiousness and demonstrates the importance of kinematic feedback and/or encouragement when working alongside athletes.

Mean concentric velocity across all repetitions in the verbal kinematic condition showed a 6.6% improvement when compared to the control condition. These improvements support previous research from Argus et al. (2), however are of a greater magnitude. These larger improvements may be due to the training status of the subjects involved (i.e. semi-professional) with research from Argus et al. (2) using elite, professional rugby union players. It has previously been detailed that training status can affect motor unit recruitment (2, 9), with more highly trained athletes being able to recruit a greater relative percentage than their lesser trained counterparts. Additionally, the greater improvements reported in the current study may also be due to exercise selection (i.e. back squat compared to the barbell bench throw). When providing verbal kinematic feedback, Argus et al. (2) utilised the barbell bench throw which utilises a relatively smaller muscle mass than the back squat. This supports previous speculation that exercises that utilise larger amounts of muscle mass may have greater scope for improvement (2). Consequently, it is suggested that feedback is provided during large, multi-joint exercises, that require increased kinematic outputs.

Like the verbal kinematic condition, visual feedback of mean concentric velocity was shown to provide a *moderate* beneficial effect when performing the back squat. This follows previous research by Weakley et al. (26) who has demonstrated an attenuation of velocity when visual feedback is provided during resistance training. This finding may be of importance for the practitioner as it suggests that kinematic feedback that is being supplied through a monitor can stimulate an athlete and enhance physical performance. It is known that external interest in an athletes training can promote kinematic outcomes (14), therefore by having an automated process that records and delivers kinematic feedback the practitioner may be able to spend additional time with individuals who require greater attention. Accordingly, the provision of a monitoring system that supplies resistance training outcomes to athletes (e.g. mean concentric velocity from a linear position transducer) may provide additional support when practitioners are coaching multiple athletes during a training session.

Verbal encouragement in the present study showed *moderate* improvements in mean concentric barbell velocity across the set when compared to the control condition. This corroborates with previous work by McNair, et al. (15) who has shown that when positive reinforcing statements are provided (e.g. "Come on, you can do it!") significant improvements in physical performance occur. When exercising, positive dissociative statements have been found to improve performance by changing focus from the physical sensations (e.g. pain, breathing) of exercise and onto the encouragement that was provided (1). Additionally, by having the researcher available and showing active interest in the exercise, performance may be positively reinforced by the subject wanting to appear favourable and ensuring maximal effort is applied. Nevertheless, despite the mechanism that has improved performance, it appears that encouraging statements promote comparable improvements in acute barbell velocity when compared to being provided kinematic feedback. This should be noted by practitioners as it demonstrates the importance of providing encouragement and feedback to athletes even in modest surroundings.

When provided augmented kinematic feedback, self-reported levels of conscientiousness were found to have *small* (i.e. verbal kinematic feedback) and *moderate* (i.e. visual kinematic feedback) inverse relationships with improvements in mean set concentric velocity. However, a *large* inverse relationship was found between differences in average set concentric velocity (when compared with control) and conscientiousness when individuals were provided verbally encouraging statements. This suggests that individuals with low conscientiousness may benefit to a greater extent from verbal encouragement when resistance training. These findings support earlier research by Binboga, et al. (6) who have shown that verbal encouragement can enhance maximal voluntary contraction in athletes with low levels of conscientiousness. It has been suggested that these improvements in physical performance occur as individuals with lower levels of conscientiousness may also exhibit lower commitment and persistence during strenuous tasks (8). Consequently, it is suggested that verbal encouragement is provided to athletes who exhibit low conscientiousness. These findings suggest that practitioners may want to assess personality traits (e.g. conscientiousness) of their athletes for understanding how best to provide feedback when coaching.

While this study is the first to compare the effects of varying forms of feedback on physical performance and conscientiousness measures, it is not without its limitations that might reduce its application to real life practice. Due to the nature of the research question, it is unknown whether differing exercises show differing physical responses to feedback and encouragement. Previous research has shown that professional male rugby union players demonstrate enhanced performance in the bench throw when being supplied verbal kinematic feedback (2), yet further investigation is still necessary to quantify the effects across a range of exercises. Additionally, the training adaptations that occur from these improved neuromuscular responses are still unknown. Previous research (2, 26) has speculated that improved kinematic outputs may enhance training "quality" and corresponding adaptation. However, due to this study investigating the acute responses from various forms of feedback, improvements in physical performance are still speculative.

In conclusion, this study presents and compares the effects of various forms of feedback when completing the back squat in semi-professional rugby union athletes. Furthermore, this study has assessed relationships between levels of conscientiousness and improvements in back squat mean concentric velocity performance. Findings showed that regardless of the manner in which feedback is provided, neuromuscular performance is enhanced and the natural decline in velocity that occurs with fatigue is attenuated. Additionally, it was shown that verbally encouraging statements had the strongest relationship with improvements in mean barbell velocity and reported conscientiousness. Consequently, it is advised that practitioners supply feedback to athletes when resistance training. This can be through verbal or visual kinematic feedback, or by verbally encouraging an individual as they train. However, the provision of verbal encouragement may be of greatest benefit for individuals who demonstrate low levels of conscientiousness.

PRACTICAL APPLICATION

Based on the current findings, the provision of kinematic feedback and encouraging statements can cause substantial attenuation of velocity across a set of the barbell back squat. It should be noted that these improvements occur irrespective of delivery method. Consequently, practitioners should ensure that when athletes are training, kinematic feedback or positive encouragement is provided. However, each method may have distinct benefits in various surroundings. For example, when utilising velocity-based thresholds (e.g. set termination occurs when participant concentric velocity dips below 0.40 $m \cdot s^{-1}$), the provision of verbal kinematic feedback may be of use. Alternatively, in settings where there is a large number of athletes training at once, setting up a monitor so that an athlete can visually observe their barbell velocity may enable a coach to assist other athletes who require additional support. Finally, the use of verbal encouragement can be used when technology is not present. Coaches and athletes alike can employ this method to support or encourage performance. This may be particularly useful in athletes with low levels of conscientiousness.

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Figure 1. Changes in mean concentric velocity (±SD) across 10 repetitions of the barbell back squat when various forms of feedback or encouragement are provided.

Table 1. Effect size (±90%CI) and inference of supplying verbal and visual kinematic feedback, and verbal encouragement compared to control condition across 10 repetitions of the back squat.