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Title: The effect of augmented feedback type and frequency on velocity-based training-induced adaptation and retention

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Abstract

The purpose of this study was to compare the benefits of 4-weeks of velocity-based training (VBT) using different augmented feedback (AugFb) types and the frequency of AugFb, and whether adaptations are retained 10 days post-training. Thirty-seven collegiate male rugby players were divided into groups that received immediate-feedback (ImFb; n=9), visual-feedback (ViFb; n=10), average-feedback (AvgFb; n=10) and no-feedback (NoFb; n=8) during each VBT session consisting of 3 sets of 5 repetitions of loaded jump squats. The ImFb group received AugFb regarding lifting velocity under loaded jump squats (LV-JS) following every jump, whereas LV-JS measures were averaged following each set of jumps and presented to the AvgFb group. The loaded jump squats were video-recorded and displayed as kinematic feedback for the ViFb group following each set, although no feedback was provided for the NoFb group. LV-JS measures were reported at baseline, during each training session and 10-days post training. LV-JS measures were significantly greater for the ImFb Group compared to the other groups during a number of post-baseline time points ($P<0.05$). Furthermore, at 4-weeks of VBT and 10 days post-retention, effect size (ES) calculations showed that LV-JS measures were greater with moderate to large effects for the ImFb group compared to the NoFb (ES=1.02-1.25), AvgFb (ES=0.78-0.82) and ViFb (ES=0.74-1.60), respectively. However, LV-JS measures were reduced with moderate to large effects 10 days post-retention for the ViFb (ES=-0.60) and NoFb (ES=-0.85) groups. Providing LV-JS feedback following each jump appears to optimize performance and should be considered as a training tool during VBT.

Keywords: jump velocity, loaded squats, knowledge of performance, knowledge of results, strength training, retention

Introduction

It is well established that muscular strength, power and speed play an imperative role in rugby performance with elite players covering 300-800m above high-speed running thresholds during match-play (12). Accordingly, appropriate training to improve these physical qualities is essential to optimise athlete's performance in rugby. Several studies have reported increased strength, power and speed in rugby players using heavy resistance training methods with training loads typically set at a percentage of 1 repetition maximum (RM) (3, 17). However, given that heavy resistance loading is implemented at the cost of reduction in lifting velocity (16), sole usage of such training methods may limit optimal power and speed developments. Monitoring the velocity of training during explosive resistance exercises at lighter loads (e.g., 30-60%1RM), referred to as velocity-based training (VBT), may be an effective additional training tool as movement is executed with emphasis on lifting velocity.

A crucial component for VBT success is to ensure that resistance exercises are performed with the intention to execute movement with maximal speed (5). Recent studies regarding VBT have also examined the use of condition management through monitoring lifting velocity during resistance training (19), and their results have demonstrated that improving lifting velocity and power output through resistance training can improve an athlete's performance, highlighting the importance of monitoring lifting velocity. Subsequently, obtaining information regarding lifting velocity during training is essential to monitor progress and provide appropriate feedback for athletes (19). Presenting an external source of information to athletes, such as lifting velocity, is referred to as augmented feedback (AugFb) (15). The concept of AugFb in the field of motor skill learning is commonly understood as two separate domains: knowledge of results (KR) and knowledge of performance (KP) (32). Knowledge of results is defined as the successfulness a skill is performed with respect to the goal of a particular movement, whereas KP is referred to information regarding the actual execution of a particular movement (15). For example, in the context of VBT, if the purpose of VBT was to improve lifting velocity with a given load, lifting velocity would be considered as KR whereas the movement patterns associated with the resultant lifting velocity would be referred to as KP.

In addition to differences in the classifications of KP and KR, AugFb can be provided immediately following each lifting repetition (ImFb), or presented as an average of a set of lifting repetitions, referred to as average feedback (AvgFb) (32). Interestingly, Keller and colleagues (10) reported greater improvement in jump height performance following 4 weeks of jump-specific training in a group that received AugFb following every jump repetition compared to a group that received AugFb for half the number of repetitions. These findings suggest that a higher AugFb frequency during explosive-based training optimises jump performance measures. However, Keller et al. (10) included non-athletic individuals with minimal explosive jump training experience, did not compare different AugFb types (e.g., KR vs KP), nor did they determine whether AvgFb differs to ImFb for VBT-induced performance changes. Examining the effect of AugFb types in a highly trained homogenous group, such as rugby players, may expand our understanding of the role that AugFb has on ballistic movement development under loaded conditions and its application to elite sports.

One of the first studies that pioneered the effects of AugFB during VBT specifically in elite rugby players was conducted by Argus et al (2), who reported improvement in bench throw performance by providing AugFb on movement velocity. However, performance measures were **limited to upper body anaerobic performance measures**. In a similar cohort of athletes, Randell et al. (19) examined the effect of instantaneous AugFb during six weeks of VBT on lower body sport-specific performance tests. The rugby players were separated into groups that received information on peak velocity during loaded concentric squat jumps following each repetition (i.e., ImFb) and a group that received no feedback.

The results showed that the **probability** of using VBT with feedback to improve performance was beneficial by 45%-99% for sport-specific performance measures, including vertical jump and sprints. Whilst these findings highlight the importance of incorporating AugFb during periods of VBT, the types of AugFb (i.e., KR vs KP), the frequency of AugFb (i.e, ImFb vs AvgFb), retention of training adaptation following VBT training and lifting velocity under loaded conditions as outcome measures were not examined. Therefore, the current study was conducted in elite rugby players to fulfil two purposes. First, to compare different AugFb types (i.e., KP vs. KR) and the frequency of AugFb on loaded vertical jump velocity following 4-weeks of VBT. Second, to determine whether training adaptations are retained 10 days following VBT training.

METHODS

Experimental Approach to the Problem

This study was conducted across 6 weeks using a quasi-experimental design. The participants undertook a 4-week VBT intervention focusing on increasing concentric loaded jump squat velocity with two training sessions completed each week. During each training session, the participants either received immediate feedback (ImFB), average feedback (AvgFB), visual feedback (ViFB) or no feedback (NoFB). The mean lifting velocity under loaded jumps squats (LV-JS) was recorded prior to the 4-week training intervention as baseline, during each training session (Wk1-T1, Wk1-T2, Wk2T1, Wk2-T2, Wk3-T1, Wk3-T2 and Wk4-T1, respectively), post training (Post-test) and ten days following the completion of the training intervention (retention) to ascertain whether improvements were retained for each group and to determine whether differences in retention rate existed between different feedback methods. All loaded jump squats during each training session were conducted using a **countermovement jump.**

Participants

The participants were 40 male rugby players (age 20.89±0.80 yrs; height 1.71±0.05m; body mass 77.82±12.56kg; 1RM back squat 153.88±24.53kg) from the Kyushu Kyoritsu University rugby club who competed in the Division 1 of the Collegiate Rugby Football League (i.e., the highest level of collegiate competition in Japan). From this sample, three participants were excluded due to injury, and thus 37 participants were separated into groups either receiving ImFB **(n = 9, 1RM back squat = 154±24.6kg; 1RM:body mass = 2.00±0.23%), AvgFB (n = 10; 1RM back squat = 157.5±21.1kg; 1RM:body mass = 2.04±0.24%), ViFB (n = 10, 1RM back squat = 154±24.6kg; 1RM:body mass = 2.08±0.43%) or NoFB (n = 8, 1RM back squat = 152.5±19.7kg; 1RM:body mass = 1.97±0.12%)** and were matched by their back squat 1RM. All participants had 3.3±1.0 years of resistance and explosive power training experience. After being informed about the purpose, testing procedures, and potential risks of the experiment, all the participants provided written informed consent. All experimental procedures were approved by the Experiment Ethics Committee of Kyushu Kyoritsu University (number; 2015-05) and were conducted in accordance with the Declaration of Helsinki.

Training Intervention

The training intervention was implemented for 4 weeks (i.e., Wk1-T1 to Wk4-T1) consisting of two training sessions per week, except for the second session during the 4th week which was utilised for Post-test (i.e., 7 total training sessions). The participants included in the analyses had 100% compliance to the 4-week VBT program. Each training session was separated by at least 48 hours to minimise carry-over effects of fatigue (6).

In conjunction with VBT, all participants undertook lower body resistance training once a week consisting back squats performed with 3 sets of 8 repetitions at 75% of 1RM, although at least 48 hours of rest was provided following each resistance training session prior to any of the VBT sessions. During each training session, the participants commenced with a progressive warm-up consisting of cycling on an ergometer (KISER m3, USA) for 5 minutes followed by leg swings and body weight jump squats. Upon completion of the warm-up, the participants performed 3 sets of 5 jump squats under loaded conditions with 15-seconds of rest in-between each repetition and 2 minutes of rest in-between each set. All participants were instructed to elevate as fast and as high as possible and to jump with their full effort. Following each set of loaded jump squats, the participants either received ImFB, AvgFB, ViFB or NoFB depending on which group they were allocated to. Each feedback method was employed with the following: AvgFb – the participants were informed of their LV-JS averaged from the 5 repetitions immediately after the completion of each set; ViFB – the participants were shown a video-recording of each repetition of their jump squat performance on a tablet using an in-built camera (Apple iPad air2, USA) immediately after each set without disclosing their velocity measures; ImFB – the participants were informed of their LV-JS immediately after each repetition; NoFB – no information was provided to the participants regarding their LV-JS (Figure 1).

Figure 1 around here

Loaded Velocity Jump Squat Performance

Each loaded jump squat repetition was performed whilst carrying a 30kg barbell on the shoulder (Figure 2). Similar loads have been prescribed to optimise lower extremity power development during VBT for elite athletes previously (19). The LV-JS was measured using an optical encoder system (GymAware, Kinetic Performance Technology, Canberra, Australia). The reported spatial and temporal accuracy were 0.03mm and 1ms, respectively, with good validity and reliability (coefficient of variation = 1.0-3.0% and correlation = 0.97-1.00) (7). Optical pulses from the digital optical encoder were continuously fed into the position counter that kept track of the current tether position. The velocity data were recorded into a tablet device (Apple iPad air2, USA) with iOS, and then transferred into a personal computer for further analyses. The participants performed 15 loaded jump squats for each session during the training period. From these repetitions, the average of LV-JS of the first set was reported, whereas participants performed 5 loaded jump squats for baseline, Post-test and retention with no feedback provided for any of the groups and the average of these measures reported. The current study specifically reported LV-JS as the primary outcome measure due to the nature of the monitoring protocol for the training program (i.e., VBT) and to align the type of AugFb with the performance parameter (i.e., velocity-based AugFb with velocity-based performance outcome measure).

Figure 2 around here

Statistical Analysis

All measurements were reported as mean±standard deviation (SD). A two-way (group x time) repeated measures analysis of variance (ANOVA) was used to assess differences in LV-JS measures between feedback groups and between time points for each condition. When interaction and/or main effects were detected, post-hoc comparisons were performed using Bonferroni procedure. The alpha level was established at $p < 0.05$ using the Statistical Package of Social Sciences (SPSS, Version 21) to conduct all statistical analyses. To determine the magnitude of differences between each feedback condition at each time point and between baseline and post-baseline time points for each group, effect size (ES) calculations (Cohen's d) were reported for all measures with 0.2 considered as a small ES, 0.5 as a moderate ES and $\geq$ 0.8 as a large ES (4).

RESULTS

For LV-JS velocity, there was a significant interaction effect (F (27,297) = 2.248, η_p = 0.170, <0.05), main effect of feedback type (F (3,33) = 4.321, η_p = 0.282, p<0.05) and a main effect of time (F (9,297)=1.312, η_p=0.038, p<0.05; Figure 3). Post hoc analyses between groups for each time point revealed significantly higher measures for ImFb than NoFb at Wk2-T2 (p=0.030) and Wk4-T1 (p=0.029), AvgFb at Wk2-T1 (p=0.040), Wk2-T2 (p=0.005) , Wk3-T1 (p=0.012) and Wk3-T2 (p=0.029) and ViFb at Wk3-T2 (p=0.042) with moderate to large effects (Table 1). Greater LV-JS measures approached significance at Wk4-T2 for ImFb compared to NoFb (p=0.058) and AvgFb (p=0.051) with moderate to large effects (ES=1.02 and 0.78, respectively). Whilst there were no significant differences between ViFb and AvgFb at Wk2-T1 (p=0.187), Wk2-T2 (p=0.275) and Wk3T1 (p=0.275), LV-JS measures at these time points were greater for ViFb than AvgFb with **large and moderate effects (ES = 1.02 and 0.78)**. During the retention test, the LV-JS measures for ImFB was significantly greater than NoFB (p=0.004) with a large effect. Furthermore, although no significant differences were reported between ViFb and NoFb during the retention test (p=0.312), ViFb was greater than NoFb with a moderate effect.

*** Figure 3 around here***

***Table 1 around here

Whilst a main effect of time was reported for LV-JS measures, no significant differences were found between baseline and any of the post-baseline time points for all groups ($p > 0.05$). However, when compared to baseline, values for ImFb were greater at Wk2-T1, Wk2-T2, Wk3-T1, Wk3-T2, Wk4-T1 and Post-test and during the retention period with moderate to large effects (Table 2). Contrarily, when compared to baseline, lower values were found for ViFb at Wk3-T1, Wk4-T1 and Post-test, for AvgFb at Wk2-T2 and Wk3-T1 and for NoFb at Wk1-T1, Wk4-T1 and during the retention period with moderate to large effects.

Table 2 around here

Discussion

The current study showed significantly greater improvements in LV-JS for ImFb compared to ViFb, AvgFb and NoFb for a number of post-baseline time points although there were minimal differences when ViFb and AvgFb were compared with NoFb. Furthermore, VBT exhibited improvements in LV-JS for ImFb at a number of post-baseline time points with moderate to large effects, although decrements were observed for ViFb, AvgFb and NoFb with moderate effects. The ImFb were also able to retain their improvement in LV-JS with a moderate effect during the retention period when compared with baseline. However, ViFb and AvgFb showed small changes in LV-JS measures during the retention period whilst significantly reduced with a large effect for NoFb.

In the current study, the improvement in LV-JS as a result of instantaneous AugFb (i.e., ImFb) compared to NoFb during a number of post-baseline time points is in line with findings reported previously by Randell et al (19). In their study, instantaneous feedback on peak velocity following each squat jump repetition was provided during a 6-week period of VBT. Their results showed greater improvement in sport-specific performance measures for the group that received instantaneous AugFb compared to a group with no AugFb. The authors speculated that AugFb may have enhanced consistency of **jump** squat performance and increased motivation during periods of training. Considering that the current study utilised similar methods of AugFb delivery, the greater improvement in LV-JS measures may have occurred due to similar mechanisms as that proposed by **Randell** and colleagues (18).

When compared between AugFb frequencies, the ImFb group exhibited greater improvement than the other groups (i.e., NoFb, AvgFb and ViFb) following four weeks of VBT. These findings confirms the results reported by Keller, Lauber, Gehring, Leukel and Taube (10). In that study, participants undertook 4 weeks of drop jump training with one group receiving AugFb regarding their jump height following every jump for each training session, one group receiving 50% of AugFb and one group with no AugFb. Following 4 weeks of training, the group who received AugFb following each jump showed the greatest improvement in jump height performance compared to the groups with 50% AugFb and no AugFb, respectively. Whilst still not fully understood, the 'guidance hypothesis' has been widely used to explain factors underpinning the effect of AugFb frequency on motor learning (13). According to this theory, greater frequency of AugFb may guide learners to optimise performance. However, a high relative frequency of AugFb may be detrimental for learning as individuals may become dependent on AugFb with difficulty in retaining any form of learning effects once AugFb is withdrawn due to a reduced reliance on essential task-intrinsic cues (20). This concept appears to contradict findings in the current study, and that by Keller et al. (10), given that higher AugFb frequency induced greater improvement in jump performance despite withdrawal of AugFb during Post-testing.

There may be several reasons for the discrepancy between the proposed 'guidance hypothesis' and the current findings. Firstly, classical studies that have examined the impact of AugFb frequency on motor learning performance have assessed the retention of motor skills that were newly acquired (30). When learning new tasks, theorists have suggested that individuals are more concerned in understanding task procedures and how performance is evaluated, rather than ascertaining the most efficient way of meeting task demands (1). Thus, a high dependency on AugFb would be expected for individuals learning new tasks, and as a result, impair performance when AugFb is withdrawn (30). Conversely, loaded jump squats were an already acquired motor task for the participants in the current study as they had undertaken this form of training for several years. Secondly, the optimal AugFb frequency may depend on the complexity of the movement task, with better acquisition using fewer AugFb frequencies for simpler motor tasks and vice versa for more complex ones. For example, Winstein and Schmidt (27) reported greater improvement in lever-patterning task performance when AugFb was reduced to 50% of practice trials compared to AugFb provided following every practice trial. Contrarily, using more complex tasks, such as slalom skiing and ski-simulator protocols, performance was enhanced to a greater extent when participants received AugFb following every trial during training compared to those with fewer AugFb frequencies during retention and transfer tests with absence of AugFb (24). Loaded jump squats, as performed in the current study, can be considered a more complex task given the multi-segmental movement patterns in conjunction with execution of movement against resistance.

In light of the above, greater improvement in LV-JS measures for ImFb may be not associated with the process of acquiring new motor tasks, but rather, optimal neural stimuli due to higher levels of motivation and a shift in focus of attention. It has previously been suggested that AugFb may increase motivation because of the desire to enhance assigned motor tasks during subsequent attempts (8). In line with this conjecture, Weakley, Wilson, Till, Read, Darrall-Jones, Roe, Phibbs and Jones (25) recently showed that AugFb elevated motivation, and as a result, concomitantly improved loaded back squat performance to a greater extent compared to conditions with no AugFb. These findings also support those of other studies that have reported acute enhancement in vertical jump performance as a result of AugFb (11, 23), with authors postulating that motivation level may have been a contributing factor. A shift in the focus of attention from an internal (e.g., proprioceptive/tactile cues) to an external (e.g., jump height/velocity) source of information has also been reported to improve anaerobic performance measures, including jump (29) and sprint performance (18). As mentioned earlier, given that the intention to execute movement with maximal speed is crucial for VBT success (5), it is possible that the ImFb group had a higher level of motivation with an external focus of attention during each jump attempt, thereby optimising training stimuli during 4 weeks of VBT. However, it should be noted that the degree to which motivation and attentional focus influences VBT-induced adaptation and retention is speculative, given that we did not examine perceptual responses to assess motivation level. Further research is warranted to determine the impact of AugFb type and frequency on motivation level during VBT and whether changes in neural recruitment patterns are observed during loaded jump squats.

When results were compared between AugFb type, LV-JS measures were greater for ImFb than ViFb for the majority of post-baseline time points, including the retention period. Considering that the ImFb group received information regarding their jump velocity (i.e., KR), it is possible that the participants relied on an external focus of attention. Contrarily, the ViFb group received kinematic information regarding their jump performance, which may encourage a shift towards an internal focus of attention thereby relying on task-intrinsic cues. According to an extensive review by Wulf et **al.** (28), external focus of attention appears to generate better outcomes for maximum force production, speed, coordination and movement efficiency, all of which are essential components for jump squat performance (14). The constrained action hypothesis was proposed by Wulf **et al.** (30) to describe the role that external attentional foci has on improving various elements of physical performance. According to this theory, attentional foci on internal sources (e.g., becoming conscious of proprioceptive feedback after viewing movement patterns of jump squats) causes individuals to become more conscious of their body control, thereby compromising the automatic control process. Conversely, attentional foci on external sources (e.g., velocity of jump squats), may assist in executing automated, fast and reflexive movements. Thus, the ImFb group in the current study may have performed jump-squats via automatic control processing with minimal interference from being conscious of task-intrinsic cues. However, it is important to note that the AugFb frequency were discrepant between ImFb **(100% of AugFb)** and ViFb **(only receiving 25% of AugFb)** in our study, and further research comparing these modes of AugFb by equating frequencies is warranted to confirm the role that attentional foci have during VBT.

The greater LV-JS measures for ImFb during the retention period when compared to baseline with a moderate ES suggests that the participants in this group were able to sustain their performance improvement as a result of their training. Shea, Wulf and Whitacre (22) suggested that retention occurs once a high level of motor learning is acquired with less dependency on receiving feedback. In the current study, given that the participants were familiar with the loaded jump squat protocol, it is more likely that training adaptations were maintained for ImFb, rather than retention of acquired skill. Several studies have in fact reported that neural adaptations from lower body explosive-based training are sustained for several weeks prior to the effect of detraining (9, 21).

Interestingly, no improvements in LV-JS were observed for ViFb and AvgFb following 4 weeks of VBT, indicating that AugFb with fewer frequencies provides no benefit for VBT-induced adaptations. These findings are contrary to previous studies that have reported improvement in jump performance (10) and power snatch performance (26) with less than

100% AugFb frequencies during several weeks of explosive-based training. The discrepancy in findings between the current study and those of others (10, 26) may be due to differences in the relative frequencies of AugFb. In the current study, given that AugFb for both ViFb and AvgFb were given after each set consisting of 5 repetitions, AugFb was provided only 20% of the time. In contrast, participants in the study by Keller et al., (10) and Winchester et al., (26) received approximately 50-65% of AugFb frequencies. Subsequently, whilst performance improvements were previously found with fewer AugFb frequencies (10, 26), their relative AugFb frequencies were greater than two-fold compared to that of the current study. Given that the current study, and those by others (10, 24, 31), have reported better performance outcomes with provision of AugFb after every single trial for complex tasks, AugFb set at exceptionally low frequencies may not exhibit any further benefits to training, but rather, impair performance. This may partly explain the comparable results found between ViFb and AvgFb in the current study, whereby AugFb frequency may have been insufficient to induce differences between AugFb types (i.e., KP vs KR). Unfortunately, ViFb and ImFb were not comparable given that these sources of information were provided at different frequencies. Subsequently, we are unable to report on recommendations for optimal AugFb type for VBT at present. Further research is needed to confirm whether ViFb (i.e., KP) set at 100% frequencies during VBT induces adaptations and whether these differ to those of ImFb (i.e., KR).

The current study showed that provision of AugFb following every jump attempt during 4 weeks of VBT optimised LV-JS, with improvements retained 10 days after VBT. No improvements were found for ViFb and AvgFb following 4 weeks of VBT, although the lack of any change in these groups may be due to low AugFb frequency rather than type of AugFb (i.e., KP vs KR). **Further studies are warranted to compare these modes of AugFb with greater frequencies per VBT training session.**

Practical Applications

The findings of the current study could be useful for athletes and coaches aiming to optimize the benefits of VBT for competitive sports with experience in loaded jump squats. The data suggests that AugFb should be provided following every jump squat during each **VBT** session to induce **acute** improvement in jump velocity performance under loaded conditions. **As a result, training stimuli appears to be increased during 4-weeks of VBT, thereby enhancing training adaptation.** In addition, KR (i.e., jump velocity) may be a more effective form of AugFb than KP (i.e., display of movement patterns) for optimizing loaded jump velocity performance. **Accordingly, coaches should consider providing AugFb, particularly information on jump velocity (i.e., KR), following every jump attempt for each training session during VBT to optimise training adaptation and improve loaded jump performance.**

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Figure captions

Figure 1. The schematic diagram of procedures implemented for each group

Figure 2. Set-up of the barbell adjustable rack and optical encoder for obtaining jump squat velocity

Figure 3. The changes in mean velocity measures across the time points from baseline, during the 4-week training intervention and the post-retention time point

Table 1. The effect size calculations (95% confidence intervals) between each group (no feedback [NoFb], visual feedback [ViFb], average feedback [AvgFb] and immediate feedback [ImFb]) based on percentage differences of loaded jump squat velocity between baseline and post-baseline time point measures (Week 1 time point 1 [Wk1-T1] and 2 [Wk1-T2], Week 2 time point 1 [Wk2-T1] and 2 [Wk2-T2], Week 3 time point 1 [Wk3-T1] and 2 [Wk3-T2], Week 4 time point 1 [Wk4-T1] and 2 [Wk4-T2] and retention period)

	ImFb - NoFb	ImFb - AvgFb	ImFb - ViFb	ViFb - AvgFb	ViFb - NoFb	AvgFb - NoFb
Wk1-T1	**0.82** (-0.18-1.75)*	**0.60** (-0.32-1.47)*	0.11 (-0.77-0.98)	**0.57** (-0.32-1.46)	**0.85** (-0.16-1.77)**	0.36 (-0.60-1.28)
Wk1-T2	**0.55** (-0.42-1.47)*	0.42 (-0.48-1.29)	0.09 (-0.79-0.96)	0.38 (-0.52-1.25)	**0.53** (-0.44-1.45)*	0.09 (-0.84-1.02)
Wk2-T1	**0.88** (-0.14-1.81)**	**1.11** (0.12-2.00)** †	0.38 (-0.52-1.24)	**0.95** (-0.01-1.83)**	**0.70** (-0.29-1.62)*	-0.08 (-1.00-0.86)
Wk2-T2	**1.12** (0.08-2.07)** †	**1.58** (0.52-2.51)** †	**0.76** (-0.18-1.63)*	**0.68** (-0.25-1.55)*	0.43 (-0.53-1.35)	-0.12 (-1.04-0.82)
Wk3-T1	**0.70** (-0.29-1.62)*	**1.31** (0.30-2.22)* †	**0.74** (-0.20-1.61)*	**0.78** (-0.16-1.65)*	0.21 (-0.73-1.14)	-0.33 (-1.24-0.63)
Wk3-T2	**0.77** (-0.23-1.69)*	**0.81** (-0.14-1.68)** †	**1.30** (0.29-2.20)** †	-0.44 (-1.31-0.47)	-0.40 (-1.32-0.55)	-0.01 (-0.92-0.94)
Wk4-T1	**0.91** (-0.11-1.84)** †	**0.60** (-0.32-1.47)*	**1.03** (0.06-1.91)**	-0.32 (-1.19-0.58)	0.14 (-0.79-1.07)	0.34 (-0.61-1.26)
Wk4-T2	**1.02** (0.00-1.97)**	**0.78** (-0.16-1.65)*	**1.60** (0.54-2.53)**	-0.31 (-1.17-0.59)*	-0.16 (-1.08-0.78)	0.14 (-0.80-1.06)
Retention	**1.25** (0.19-2.20)**	**0.82** (-0.12-1.70)**	**0.92** (-0.03-1.80)**	-0.16 (-1.03-0.72)	**0.70** (-0.29-1.62)*	**0.68** (-0.31-1.60)*

Bold letters denoting moderate to large effect size

* Moderate effect size; ** Large effect size

† Significantly different ($p < 0.05$)

Table 2. The effect size calculations (95% confidence interval) with p-values based on Tukeys post hoc test between baseline and post-baseline time point measures (Week 1 time point 1 [Wk1-T1] and 2 [Wk1-T2], Week 2 time point 1 [Wk2-T1] and 2 [Wk2-T2], Week 3 time point 1 [Wk3-T1] and 2 [Wk3-T2], Week 4 time point 1 [Wk4-T1] and 2 [Wk4-T2] and retention period) of loaded jump squat velocity for the immediate feedback (ImFB), visual feedback (ViFB), average feedback (AvgFB) and no feedback (NoFB) groups

Time points	ImFB	ViFB	AvgFB	NoFB
Baseline vs Wk1-T1	0.43 (-0.52-1.35)	0.37 (-0.53-1.24)	-0.20 (-1.07-0.69)	**-0.53** (-1.50-0.49)
Baseline vs Wk1-T2	0.38 (-0.57-1.29)	0.34 (-0.56-1.21)	-0.06 (-0.93-0.82)	-0.18 (-1.16-0.81)
Baseline vs Wk2-T1	**0.70** (-0.28-1.61)*	0.38 (-0.52-1.24)	-0.48 (-1.35-0.42)	-0.31 (-1.28-0.69)
Baseline vs Wk2-T2	**0.76** (-0.23-1.67)*	0.00 (-0.88-0.88)	**-1.11** (-2.00-0.13)**	-0.42 (-1.39-0.59)
Baseline vs Wk3-T1	**0.58** (-0.39-1.50)*	-0.11 (-0.98-0.77)	**-1.28** (-2.19-0.27)**	-0.31 (-1.28-0.69)
Baseline vs Wk3-T2	**0.64** (-0.34-1.55)*	**-0.65** (-1.52-0.28)	-0.33 (-1.19-0.57)	-0.34 (-1.31-0.66)
Baseline vs Wk4-T1	**0.50** (-0.46-1.41)*	**-0.74** (-1.61-0.20)	-0.38 (-1.25-0.52)	**-0.70** (-1.67-0.35)*
Baseline vs Wk4-T2	**0.79** (-0.21-1.70)*	**-0.60** (-1.47-0.32)	-0.26 (-1.13-0.63)	-0.38 (-1.34-0.63)
Baseline vs Retention	**0.69** (-0.29-1.61)*	-0.20 (-1.07-0.68)	-0.33 (-1.20-0.57)	**-0.85** (-1.83-0.21)**

Bold letters denoting moderate to large effect size

* Moderate effect size

** Large effect size

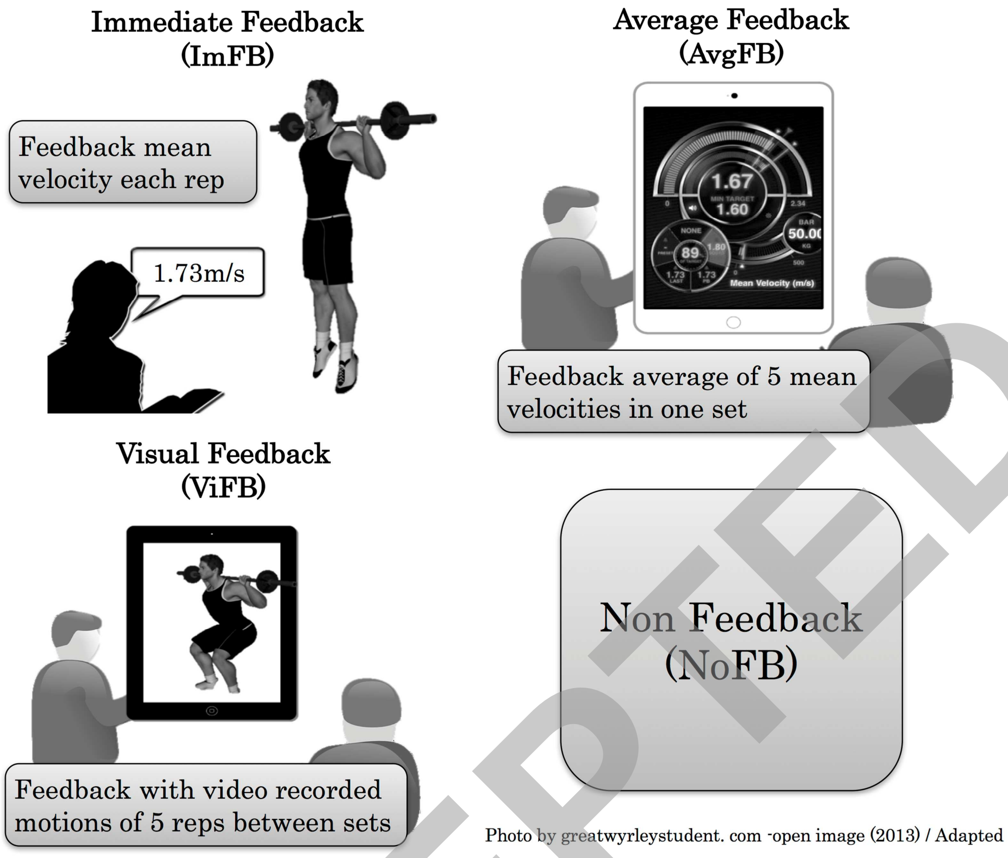
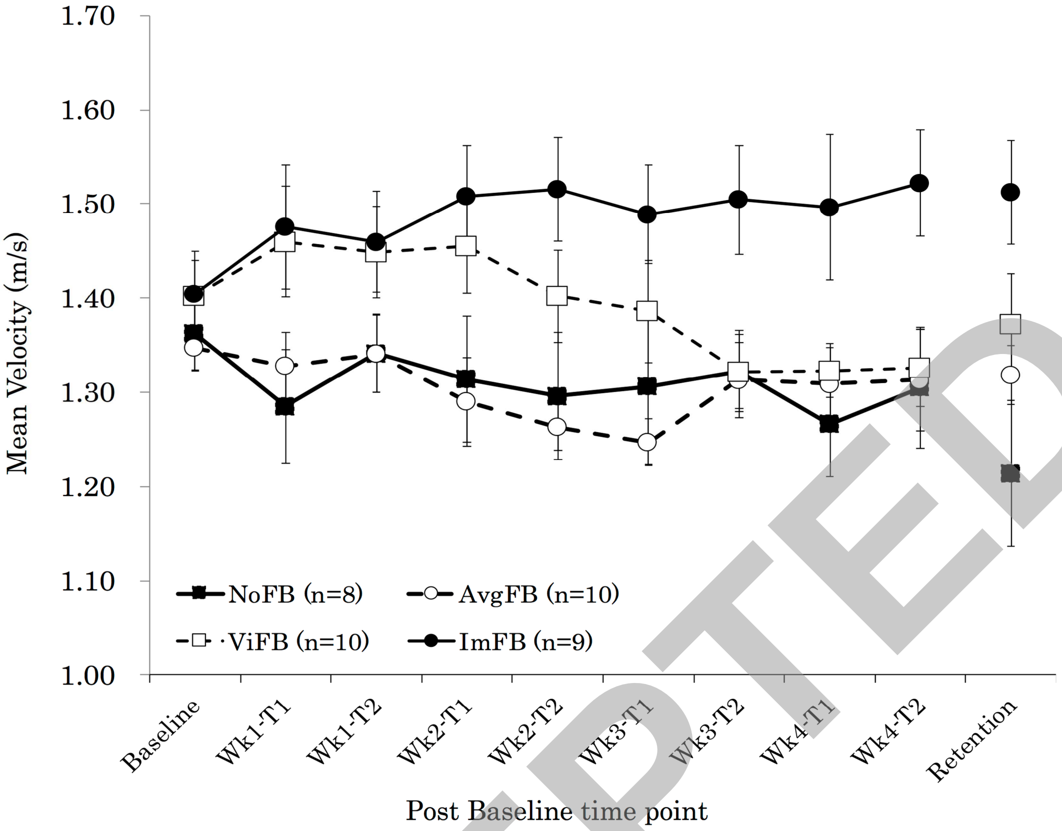


Photo by greatwyrleystudent. com -open image (2013) / Adapted



1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
Mean Velocity (m/s)
NoFB (n=8)
AvgFB (n=10)
ViFB (n=10)
ImFB (n=9)
Baseline
Wk1-T1
Wk1-T2
Wk2-T1
Wk2-T2
Wk3-T1
Wk3-T2
Wk4-T1
Wk4-T2
Retention
Post Baseline time point