

Effect of visual feedback and verbal encouragement on concentric quadriceps and hamstrings peak torque of males and females

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The purpose of this study was to determine the effect of visual feedback and verbal encouragement on concentric peak torque of the quadriceps and hamstrings muscles of males and females at an isokinetic velocity of 60 deg/s. All testing was performed on the Biodex B-2000 isokinetic dynamometer in three sessions, separated by 7 to 14 days. Fifteen males and 15 females (age = 25.4 ± 2.4 yrs, wt = 76.6 ± 16.5 kg, ht = 173.61 ± 9.5 cm) were tested under the following conditions: (a) visual feedback, (b) verbal encouragement, (c) combined visual feedback and verbal encouragement, and (d) no feedback (control). Testing order was counterbalanced to control for possible learning effects.

Two separate 2×4 repeated measure analyses of variance (ANOVA) were used to examine the difference among test conditions. Examination of quadriceps force production revealed that subjects generated greater peak torque when visual feedback was provided than when verbal encouragement or no feedback were provided. Similarly, quadriceps force production was greater when combined visual feedback and verbal encouragement was provided than when verbal encouragement or no feedback were provided ($p < 0.05$). Examination of hamstrings force production revealed that subjects generated greater peak torque when combined visual feedback and verbal encouragement was provided than when verbal encouragement, and no feedback were provided. Additionally, hamstrings force production was greater when visual feedback was provided than when no feedback was provided ($p < 0.05$). These results indicate that the use of visual and combined visual and verbal feedback increased

quadriceps and hamstrings force production when compared to the control condition where no feedback was provided.

Keywords: Strength training, biofeedback, knee, isokinetic, muscle

1. Introduction

In today's fast moving and competitive society sport and nonsport participants along with allied health professionals are constantly seeking innovative ways to maximize human potential via utilization of physiological, psychological, and other ergogenic aids. Imagery, proprioceptive training and biofeedback techniques such as verbal encouragement and visual feedback are frequently utilized for performance enhancement.

Biofeedback involves monitoring and recording the physiological events associated with the body's response to an internal or external stress. Biofeedback techniques often include utilization of computer interfaced equipment to monitor changes in physiological events such as heart rate and muscle activity. These changes in physiological events can then be converted into auditory and visual signals, and revealed to the tested individual [1,2]. Visual and auditory feedback enhances recognition of alterations in a physiological parameter. For example, change in heart rate may be depicted as a change in the pitch of an auditory signal [1]. Biofeedback, commonly used by athletes trying to reduce anxiety and stress is becoming standard protocol in exercise and rehabilitation [2]. Isokinetic

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force output data may be revealed visually via multicolored bar graphs and torque curves to provide motivation and reinforcement during exercise and rehabilitation. Biofeedback via visual feedback, verbal encouragement, and combined verbal encouragement and visual feedback have been shown to improve peak torque scores (Nm) [3–13].

Visual feedback has the potential of improving performance and increasing the effort of the user during rehabilitative exercise [3–8,10,13,14]. Visual feedback has been proven to increase maximal peak torque levels. Figoni and Morris [6] found that following visual feedback isokinetic peak torque output increased by 12% at 15 deg/s, but did not improve peak torque at 300 deg/s. Hald and Bottjen [8] investigated the effect of visual feedback on quadriceps and hamstrings peak torque output. Results revealed that visual feedback improved maximum torque output of both quadriceps and hamstrings by 6% at of 60 deg/s and by 3% at 180 deg/s. Including visual feedback in rehabilitation regimens may result in increased sport performance and allow individuals of all skill levels to maximize their efforts.

Verbal encouragement is standard protocol during isometric, isotonic, and isokinetic muscle testing and training, particularly when the goal is to increase muscular output. Verbal encouragement that consisted of loud verbal commands has been shown to increase isometric peak torque values as much as 5% [9]. McNair, Depledge, Brett Kelly, and Stanley [11] reported that isometric mean peak torque values significantly increased following verbal encouragement. Bickers [15] in 1993, investigated the effect of verbal encouragement on a motor endurance task. Verbal encouragement increased performance by 39%. Conversely, evidence also indicates that aggressive verbal encouragement initially increases torque values, but may contribute to an earlier rate of fatigue during isometric exercise testing [9].

Research involving combined verbal encouragement and visual feedback when incorporated with strength training or orthopaedic rehabilitation is limited [12, 14]. To date biofeedback research results have failed to identify differences between males and females when responding to biofeedback utilized in strength training [3–6,8–13,15]. It has been proven that males and females respond to the same external stimuli differently [16–18]. Consequently, biofeedback may or may not benefit both genders in a similar fashion.

Differences in motivation and competitiveness for completing a task exist between gender. In general,

males are more competitive than females [16–18]. It has been suggested that female athletes are more intrinsically motivated than male athletes. Conversely, male athletes displayed higher levels of non-self-determined extrinsic motivation and were more competitive [19, 20].

Obvious differences in gender characteristics (e.g. increased muscle mass, differences in endocrine secretion) have been shown to effect muscular and sport performance [21]. Therefore, males and females may react differently to training methods and external stimuli when strength is assessed isokinetically. The lack of research regarding how males and females react to visual feedback, verbal encouragement, combined visual feedback, and verbal encouragement warrants further investigation. The purpose of this study was to investigate the effect of visual feedback and verbal encouragement on concentric quadriceps and hamstrings peak torque of males and females.

2. Methods

The study was reviewed and approved by a University Committee for the Protection of Human Subjects. Subjects were 15 male and 15 female volunteers from the greater Philadelphia area, (M age = 25.4 ± 2.4 yr, M wt = 76.6 ± 16.5 kg, M ht = 173.61 ± 9.5 cm). Volunteers who denied a history of lower extremity pathology or pain within the last year, or any predisposing cardiovascular or cardiorespiratory conditions were selected as participants for this study. All subjects read and signed a participant informed consent form prior to participation in this study.

2.1. Instrumentation

The Biodex B-2000 Isokinetic Dynamometer (Biodex Medical Systems, Shirley, NY), a multi-joint testing and rehabilitation system was used in the collection of quadriceps and hamstrings peak torque data. Strict adherence to the published guidelines of the Biodex B-2000 Isokinetic Dynamometer Operations Manual were followed.

Calibration of the Biodex B-2000 Isokinetic Dynamometer was completed at the start of data collection and after every sixth subject was tested.

2.2. Procedures

Upon arrival at the laboratory, subjects read, and signed an informed consent form, were assigned an identification number, and body height, and body weight were recorded. Subjects were instructed to avoid participating in lower extremity exercise or any fitness activities during the data collection period.

Subjects were seated on the Biodex B-2000 Isokinetic Dynamometer with a hip angle of 110 deg flexion. Intratester goniometric reliability for measuring hip position was $r = 0.95$. The depth of the seat was adjusted to allow the alignment of the lateral femoral condyle of the right knee with the axis of the dynamometer. The calf pad was placed 2 inches proximal to the lateral malleolus and secured with the padded shin strap. Subjects were stabilized with thigh, pelvic, and shoulder straps. Shoulder straps were applied diagonally across the chest with the subject's arms crossed and their palms touching opposite shoulders to attenuate excessive upper body movement and muscular substitution. A strap was also applied across the lap and the involved thigh in order to minimize excessive lower body motion. All positions were recorded for consistency and reproducibility for consequent practice and data collection sessions. Range of motion limits were set from 90 deg of knee flexion to -5 deg full extension. Goniometric reliability for measuring knee flexion and knee extension was $r = 0.94$. Practice and data collection testing sessions consisted of a warm-up of four submaximal (50% effort) repetitions, and one maximal (100% effort) repetition, a rest period of one minute, followed by five maximal (100% effort) concentric repetitions at 60 deg/s.

Testing was accomplished in two data collection sessions. Each day subjects were tested under one condition, then given a 15 min rest period before being tested under the next counterbalanced condition. Standardized instructions were read to each subject before warm-up and exercise bouts. Peak torque values of knee flexion and extension were assessed and recorded for each participant on the Biodex B-2000 Isokinetic Dynamometer.

A minimum of 7 days and a maximum of 14 days were required between practice sessions and data collection sessions. A seven day period was chosen to eliminate a training effect [22], and also to reduce delayed onset muscle soreness which could have influenced results. The practice sessions involved no visual feedback or verbal encouragement. Sixty deg/s was selected because it is used clinically for strength

measurements and would allow for comparison with previously published research [23].

A computer monitor was placed one meter directly in front of the subject at eye level for those experimental conditions requiring visual feedback. Subjects were instructed to carefully observe the monitor. A torque curve graph display of the torque output was provided via the Biodex B-2000 Isokinetic Dynamometer color graphics monitor. The monitor allowed subjects to directly view their performance with each repetition during the visual feedback conditions. Verbal encouragement consisted of the investigator giving positive verbal commands encouraging the subject to push (knee extension) and pull (knee flexion) throughout the entire muscle contractions. The combined visual feedback and verbal encouragement conditions consisted of the aforementioned data collection with both the computer monitor in view and the investigator instructing the subject to push or pull. The control or no visual feedback or verbal encouragement condition consisted of the same procedure described above with the monitor removed and no encouragement from the investigator.

3. Results

Two, 2×4 ANOVA's with repeated measures were performed to assess if significant differences existed between males and females and within treatment conditions. SPSS Version 7.5, (Chicago, IL) was used for data analysis. Significance was accepted at the $p < 0.05$ probability level. Tukey HSD post-hoc tests were performed when significant main effects were revealed to determine where significant differences occurred. Means and standard deviations for all test conditions are listed in Table 1. Analysis of quadriceps data revealed a significant main effect for gender ($F_{1,28} = 815.35$). Males generated greater quadriceps peak torque compared to females. There was a significant main effect for condition ($F_{3,84} = 8.80$). Results indicated that concentric quadriceps peak torque production of both males and females increased significantly when: visual feedback, and combined visual feedback and verbal encouragement were compared to the no feedback (control), and verbal encouragement condition. Analysis of hamstrings data revealed that there was a significant main effect for gender ($F_{1,28} = 108.41$). Males generated greater hamstrings peak torque when compared to females. There was a significant main effect for condition ($F_{3,84} = 6.58$). Results indicated that concentric hamstrings peak torque production of both males

Table 1
Means and standard deviations for quadriceps and hamstrings peak torque data of the four test conditions for males and females

	C		VF		VE		VE & VF	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Quadriceps								
Males	215.98	47.33	233.14	49.30	214.66	42.09	226.90	39.37
Females	141.52	27.92	150.00	30.02	142.50	26.47	109.36	23.97
Hamstrings								
Males	132.61	19.20	137.33	20.29	133.74	14.91	143.24	15.64
Females	79.70	13.02	84.59	14.85	80.28	14.20	83.06	11.36

C = Control

VF = Visual Feedback

VE = Verbal Encouragement

All Torque Values in Nm.

and females was increased significantly when: visual feedback, and combined visual feedback and verbal encouragement were compared to the no feedback (control) condition; and when visual feedback, and combined visual feedback and verbal encouragement were compared to the verbal encouragement condition.

4. Discussion

The results of the present study indicate that males produced greater concentric quadriceps and hamstrings peak torque when compared to females regardless of the experimental condition. More importantly, regardless of gender all subjects produced significantly greater quadriceps and hamstrings peak torque values when provided with visual feedback, or combined visual feedback and verbal encouragement.

The findings of the present study with regard to greater quadriceps and hamstrings peak torque production of males than females may be attributed to males being stronger than females as a result of having a larger percentage of lean body mass and greater muscle cross sectional areas [24]. Males also have larger type I muscle fibers and mean fiber areas than females [24–26]. These findings also concur with those of Griffin, Tooms, Vander-Zwagg, Bertorini, and O'Toole [27]; Nicholas, Robinson, Logan, and Robertson [28]; Wagner, Housh, Weir, and Johnson [29] who all found that males produced greater concentric isokinetic peak torque values than females. Specifically, females in our study were 64–66% and 57–60% as strong as males when quadriceps and hamstrings peak torque values were compared. These results are similar to values reported previously for comparable age groups [30,31].

Results of the present study regarding concentric peak torque production of males and females and vi-

sual feedback are consistent with the findings of Baltzopoulos et al. [3]; Carlson et al. [5]; Figoni and Morris [6] and Hald and Bottjen [8]. Results of the aforementioned studies indicated that concentric peak torque production increased when subjects were provided visual feedback. Similarly, Kellis, and Baltzopoulos [10]; and Lukasiewicz [14] found eccentric peak torque production increased when subjects were provided visual feedback.

Significant changes in peak torque production were not revealed in the present study when verbal encouragement alone was utilized. However, the results of previous studies involving verbal encouragement conflict with the results of the present study. Johansson et al. [9]; McNair et al. [11]; and Peacock et al. [12] revealed significant increases in isometric peak torque production when subjects were provided with verbal encouragement. Matheson et al. [32], also revealed significant increases in concentric back extension peak torque values of females with high demand verbal instructions. Conversely, Lukasiewicz [14] revealed decreases in eccentric peak torque production of both males and females when verbal encouragement was utilized.

The non-significant results of the present study with regard to verbal encouragement may have been due to the verbal encouragement source. During testing, subjects appeared to synchronize knee extension and flexion with the encouragement thus inhibiting maximal muscular force. The conflicting results of previous studies and the results of the present study could have resulted from the difference between static/isometric and dynamic/isokinetic testing. Motivation to perform maximal voluntary concentric or eccentric contractions compared to performing maximal voluntary isometric contractions could have influenced the results. It must also be noted that although every attempt was made to

standardize the verbal encouragement condition, individual characteristics of the investigator may have influenced subjects' performances. Results of the present study with regard to combined visual feedback and verbal encouragement are consistent with the results of Peacock et al. [12] and Lukasiewicz [14] who also revealed increases in quadriceps and hamstrings peak torque production. However, Peacock et al. [12] utilized isometric exercise while Lukasiewicz [14] utilized eccentric isokinetic exercise.

We anticipated gender effects on the four conditions for the following reasons: competitiveness, perception of effort, and motivation [16,17,19,20,33–35]. The aforementioned studies indicated that males are more competitive and more extrinsically motivated than females, therefore we speculated that these differences would affect the results of the present study. However, no significant differences were found under any of the tested conditions.

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