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Effect of Visual Feedback on Muscle Endurance in Normal Subjects

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Abstract. The measurement of maximum voluntary isokinetic contraction is a common practice in research and clinical settings. The purpose of this study was to investigate the effect of visual feedback on muscle endurance. Subjects were 22 male, between the ages of 18 and 31. Each subject had no history of lower extremity joint injury, surgery, or disease. All subjects completed two isokinetic exercise test sessions. The tests consisted of 50 maximum voluntary isokinetic contractions, using dynamometer (KIN-COM500H) at 90 degrees per second. All left lower extremities were measured. On endurance and effects fatigue index of visual feedback and no visual feedback were compared about every tenth average peak torque. On comparisions between with and without visual feedback were analyzed using a paired t-test. On average between 11th and 20th repetitions, average peak torque with visual feedback was significantly greater than without visual feedback ($p<0.05$). Excepting average torque between 11th and 20th repetition the results indicated no significant difference between with and without visual feedback. The fatigue index with feedback was not significantly different from that without visual feedback. These results suggest that visual feedback does not influence the fatigue index in measurements of muscle endurance.

Key word: Visual feedback, Muscle endurance, Maximum voluntary isokinetic contraction.

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INTRODUCTION

Research on biofeedback started in the 1960's. Marinacci established the foundation and Basmajian developed it[1)2)]. Basmajian[3)4)] defined Biofeedback as the method that attempts to control various psychological phenomenon that are involuntary in the human body and cannot be detected which would otherwise be controlled using electrical instruments operating on visual and auditory signals. Biofeedback is applied in clinical sciences in medicine and psychology and is utilized in various forms such as the muscle strength-measuring instrument, KIN-COM and the muscle trainer, CYBEX.

There have already been some reports on the effect of muscle training using Electromyographic Biofeedback (hereafter referred to as EMG-BF). Joseph[5)] and others performed muscle training on 30 female students using the quadriceps femoris and isometric contraction, and when comparing the cases in which EMG-BF was and was not used, they found that the case in which EMG-BF was applied, showed a significant increase in training efficiency. Also, according to Takemasa et al.[6)], usual muscle training and training using visual and auditory feedback as an EMG-BF was performed with 3 healthy males and 39 females and the effects were compared and examined. In the case of EMF-BF training, there was a significant increase in muscle strength, however, in the cases in which auditory feedback and visual feedback were applied, there were no significant differences in increase before and after the training among the two.

Despite numerous research and reports on the effects of Biofeedback muscle training having been completed, the subject of muscle endurance has seldom been covered. Therefore, in the current study we have measured muscle endurance, the average peak torque value and the fatigue index for the cases in which visual feed back was (hereafter referred to as V.F.B) applied and the cases in which visual feedback was not (hereafter referred to as N.V.F.B) applied to the same subject and carefully compared and examined the extent of the effect.

METHODS

Subject

The subjects were 22 males. Each subject had no history of lower extremity joint injury, surgery, or disease. No subject had any cardiac condition and none had participated in professional, or semi-professional sports. The mean, standard deviation of the subjects' age (range), height and weight were 22.1 ± 3.4 yr (18–31 yr), 171.8 ± 3.4 cm (160–185 cm), and 64.9 ± 11.4 kg (53–98 kg), respectively.

Procedure

The isokinetic loading device used for the data collection was the KIN-COM500H (CHATTEX Crop). All the left lower extremities were measured. Subjects were seated with the back and seat on the dynamometer chair seat. The pelvis was stabilized by a Velcro strap placed over the anterior superior ilar spinens. A second strap was used to stabilize the medial left thigh. The pad on the lever arm of the KIN-COM was attached with a Velcro strap to the anterior aspect of the distal tibia two finger widths proximal to the malleolli. Subjects were allowed to grasp the side of the bench by their hips for added stability. The lever arm of the device was attached to the tibia and subjects performed a knee extension from 75° flexion to 15° extension. The motion range of the lever arm was from 60° flexion to 0° extension. The axis of rotation of the dynamometer was aligned midway between the lateral condyle of the tibia and the lateral epicondyle of the femur consistent with the anatomical axis of the knee joint. A force transducer was set 5 cm above the lateral condyle of the fibula. On the first test session, the position of the axis of rotation, seating and force transducer was recorded for each subject, which was reappearance. The tests consisted of 50 maximum voluntary isokinetic contractions, using a dynamometer at 90°/s. Verbal commands were used during the test session. A constant volume and tone level was maintained during all testing. In this apparatus, the monitor was involved with elgoarm, which was set up from the seat to the position of about 1.1 m in height and 0.7 m in length.

The subject was instructed to watch the monitor which showed of a torque output display. The torque value was provided with only V.F.B session. Moreover, the peak torque values of 50 times were displayed to every five times (about 1.8 cm in the width in the bar chart) on the monitor screen. Each subject participated in two sessions. The subjects were divided into two groups of A and B at random.

Group A members performed with visual feedback at the first session and without visual feedback at the second session. Group B members performed in the reverse order of the group A sessions. At least 48 hours elapsed between test sessions. At the beginning of the first session, informed consent was obtained. Subjects were instructed not to begin any new exercise or training programs during the testing period but were allowed to continue with their present levels of activity. Subjects were asked to leave the feel of fatigue, and measured. The test protocol was as follows:

1) Warm up session of 5 submaximum voluntary contractions.
2) Subjects rest for 1 minute on the KIN-COM seat.
3) Test; 50 maximum voluntary contractions.

Data analysis

The peak torque and the fatigue index were measured. In the fatigue index of this study, a least-squares regression was applied to the actual work done in all repetitions. The fatigue index was calculated as the ratio of the predicted work done in the last repetition compared to the first

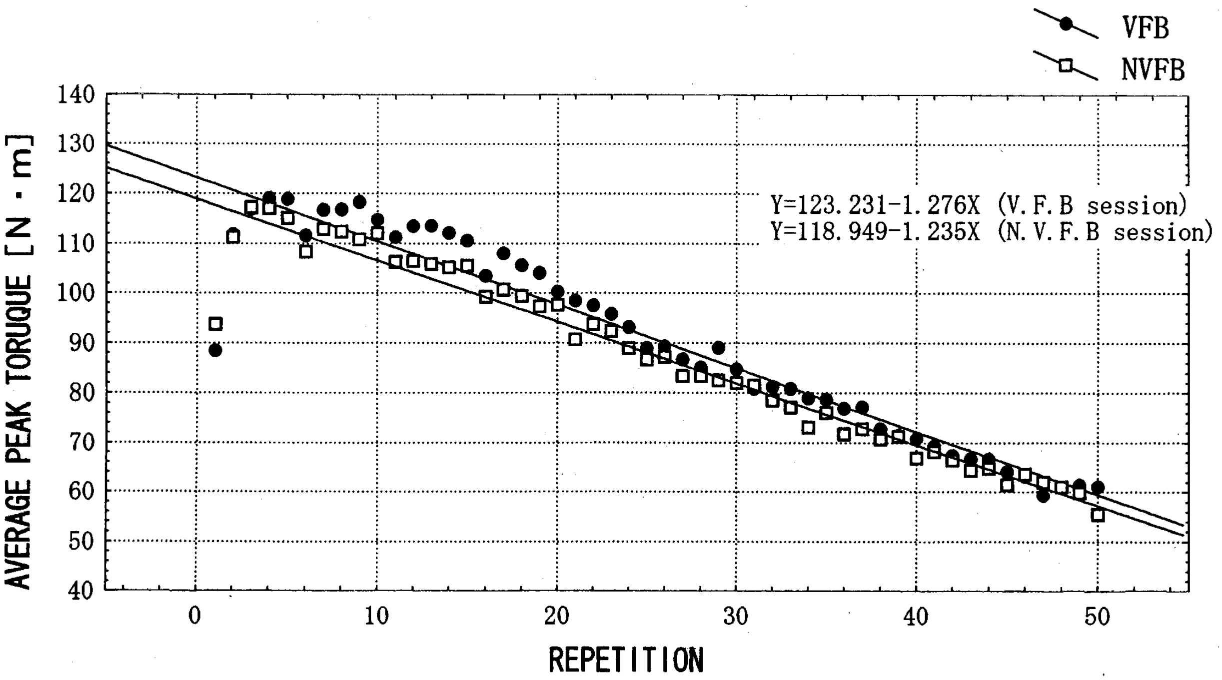

Fig. 1. Endurance curves of VFB session and NVFB session.

Table 1. V.F.B session and N.V.F.B session of every 10 times average peak torque. n=22 [N·m]

session	V.F.B	N.V.F.B
1~10	113.5 (24.7)	110.8 (25.0)
11~20*	108.0 (27.0)	101.9 (28.0)
21~30	90.2 (25.1)	86.7 (25.9)
31~40	76.0 (24.3)	73.7 (23.4)
41~50	63.2 (19.5)	62.5 (20.6)

Values are reported as mean (SD). Significant differences, $*p<0.05$

Table 2. Fatigue index of V.F.B session and N.V.F.B session. (n=22) [%]

session	average	SD
V.F.B	44.9	13.0
N.V.F.B	43.8	15.4

repetition and expressed as a percentage. Effect of V.F.B and N.V.F.B were compared about every tenth average peak torque and the fatigue index. Comparisons between with and without visual feedback were analyzed using paired t-test.

RESULTS

Figure 1 shows the fatigue curves of V.F.B and N.V.F.B sessions. In the peak torque of V.F.B session, the maximum value was 119.0 ± 26.0 [N·m] (4th), and the minimum value was 59.4 ± 19.7 [N·m] (47th). In the peak torque of N.V.F.B session, the maximum value was 117.3 ± 27.3 [N·m] (3rd), and the minimum value was 55.5 ± 16.0 [N·m] (50th). (average torque ± SD).

Simple linear regression of V.F.B session was $Y=123.231-1.276X$, and that of N.V.F.B session was $Y=118.949-1.235X$.

Table 1 shows every tenth average torque. In average torque between 11th and 20th, repetition average peak torque with visual feedback was significantly greater than that without visual feedback ($P<0.05$). Excepting average peak torque between 11th and 20th repetition, the results indicated no significant differences between with and without visual feedback.

Table 2 shows the fatigue index. The fatigue index with feedback was not significantly different from that without feedback.

DISCUSSION

This research examines how maximum voluntary contraction of muscle strength is affected by visual feedback.

1. On Endurance Curve and Average Peak Torque Value.

In this research, 50 peak torque values of the endurance curve were divided into 5 sections and the average value of each section was taken to examine the effects of visual feedback. It can be inferred that the reason why there was no significant difference between the average peak torque value of the 1st to 10th repetition of V.F.B and N.V.F.B sessions was because central fatigue or peripheral fatigue had not yet occurred. However, between the 11th and 12th repetition average peak torque with visual feedback was significantly greater than without visual feedback ($p<0.05$). Noda[7] is researching on how information by visual feedback controls muscle output power from the viewpoint of change in the lignition style of the neuromuscular unit. He reported that isometric contraction was performed using the interossei dorsales of a normal person and 2 seconds after tension was balanced at a certain level, visual feedback was masked and the change in lignition frequency of each neuromuscular unit was examined. When visual feedback information was cut off, all neuromuscular units lowered their lignition frequency and when visual feedback information was resumed, lignition frequency recovered to its original level. From this, it can be inferred that visual feedback invigorates the excitement level of the cerebral cortex and with that, a considerable increase in launching frequency of the impulse to the neuromuscular units and the number of neuromuscular units playing a part in muscle contraction[2][8]–[11] resulting in a higher torque value. After maximum voluntary contraction passed the 20th repetition, average peak torque values in the V.F.B session and N.V.F.B session showed no significant differences. This is attributed to the fact that although centripetal impulses resulting from visual feedback go to the cerebral cortex, fatigue of the central system itself, lack of energy resources of the peripheral system, accumulation of fatigue substances (lactic acid, carbon dioxide, etc.), accumulation of waste heat, and disorder in the balance of various physiological functions (body fluid, nerve system, endocrine system etc.) prevent differences emerging between the two sessions. Also, as far as voluntary action is concerned, even when conscious maximum fatigue is reached, the physiological limit[1][3][10]–[13] is not reached because of the restraint system.

2. On Fatigue Index

In this study, fatigue index was computed applying the least squares method, however, significant differences between the two sessions could not be confirmed. Thus, whether visual feedback had any effect on muscle endurance could not be confirmed either. This same result was published with the index by Ronnie, et al.[14] in which knee flexion isokinetic contraction was done 30 times and fatigue index was computed using SDI (Strength Decrement Index) that Clarke et al.[15] defined. However, there was no significant difference between the two and came out with the same result as this study. It can be said that the reason, as was referred to previously, is that although by visual feedback, visual information arrives at the cerebral cortex through the centripetal impulse, as maximum voluntary contraction is repeated, central and peripheral fatigue occur and as a result, there was no significant difference in the fatigue index between the two. On the other hand, according to research of Granves et al.[16], isometric contraction was performed on thumb flexion and when endurance of V.F.B. session and N.V.F.B session was compared, the fatigue index of V.F.B. session was signifcantly lower than that of the N.V.F.B session ($p<0.01$). In this study, the result was different from that of Granves', however, this is attributed to the difference in measurement options, the method that was used to cause fatigue, and the muscle contraction form. However, the reason why, depending on which body part was used for measurement, the effect of feedback differed could not be made clear. This is thought to be an issue for our future research.

Many people have voiced their thoughts on the definition of a fatigue index[17][18], however, in this research, as was done in the research of Gleeson et al.[19], the fatigue index was calculated by the least squares method. This is because it was thought that while Clarke's SDI formula uses peak torque values at the beginning and end, the fatigue index calculated using the least squares method uses each peak torque value and by this, a more objective endurance index can be acquired.

In this research, the effect of visual feedback on average peak torque value and endurance index was examined. However, the effect of feedback on connection time, workload, and the endurance curve will be the focus of our future studies, together with the difference in effects of feedback depending on the various types of muscles and electrical psychological consideration.

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