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Case Series

Randomized Control Trial: Pilot Study Testing Handgrip Strength Affected by Augmented Feedbacks

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ABSTRACT

Background: Hand grip strength is a standard method to measure impairment, which is a component of body function of high importance. Feedback appears to affect the performance of hand grip strength.

Objectives: To determine the effects on peak grip force with the use of visual feedback, visual conflicted feedback and without feedback, using a hand held dynamometer.

Study design: One group repeated measures design.

Case presentation: Data was collected from healthy subjects aged from 21 to 35 on the effect of feedback conditions. Subjects received counter-balanced block design test their peak grip force with three conditions, visual feedback, visual conflicted feedback and without feedback, on the same day. Hand held dynamometer was used for measuring and recording the peak grip force. The repeated measure analysis of variance was used to investigate the effect of feedback conditions within subject.

Result: 16 healthy subjects were recruited, 3 were excluded because they didn't meet the inclusion criteria in the screening process, and 3 were excluded due to unsustainability of the data. The average peak grip force for without feedback was (54.22 ± 4.0) lbs., for visual feedback was (62.59 ± 3.9) lbs., and for visual conflicted feedback was (53.22 ± 3.9) lbs. There were statistically significant differences between visual feedback and visual conflicted feedback (P=0.001), and between visual feedback and without feedback conditions (P=0.015). There was no statistically significant correlation between visual learning preference score and visual feedback.

Conclusion: subjects exerted higher peak grip force when visual feedback was provided than without feedback or visual conflicted feedback. Therefore, clinicians may benefit from using visual feedback in clinical practice.

Limitation: the way that visual conflicted feedback was provided was different from the way the literature described.

Keywords: Hand held dynamometer; Visual feedback; Peak grip force; Pilot study.

INTRODUCTION

Hand grip strength is according to, a standard method to measure impairment, which is a component of body function of high importance, and is categorized in the International Classification of functioning, disability, and health. Adequate hand function and strength is essential in execution of activities of daily living, and other work related tasks. The measurement of hand grip strength is simple; however, it can be affected by a number of internal and external factors [1]. Internal factors being related to physical characteristics and external factors involve the environment such as different forms of feedback provided (e.g. visual). To measure hand grip strength, a biofeedback method is well recognized, for instance using a hand held dynamometer, which offers the ability to quantify hand grip strength. Biofeedback being used in neurological rehabilitation with clinical success, resulting in enhancement of dynamic balance.

When hand grip strength is assessed with a hand held dynamometer, various forms of feedback can be provided to the individual whose strength is being assessed; how the feedback

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influence motor performance is of highly relevant for determining the clinical efficacy not only of the hand held dynamometer, but also for therapeutic interventions, with the goal of improving hand function and strength.

Adequate use of each sensory feedback is dependent upon the age of the performer and the motor task in order to obtain satisfying execution of the motor task at hand [2]. The focus in our study lies on studying the effects on motor performance; peak grip force, with providing three different feedback conditions while knowing the individual's preferred learning style.

Explains the importance of visual feedback as being a crucial source of sensory information for the control of motor learning, skill acquisition, and the detection of errors in performance. The visual feedback condition in fact produced a statistically significant stronger grip strength using a digital dynamometer. However, that we understand actions not only by visual recognition, but also motorically. Kinaesthetic Motor Imagery (KMI) activates the same brain regions as those used during motor performance. When performing a task with no external feedback provided, KMI can be useful because it is defined as mental execution of an action, and the individual can sense how this action feels [3]. Explain that kinaesthetic motor imagery also influences anticipatory adjustments of the motor task, and the ability to correct performance of the motor task during execution. Stinear, Byblow, Steyvers, clearly demonstrate muscle specific and temporally modulated facilitation of the corticospinal pathway during motor imagery using a kinesthetic strategy, but not during motor imagery using a visual strategy

But what happens when there is a conflict between sensory and motor information during motor performance? The brain's attempt to solve such a conflict often gives rise to cross modal perceptual illusions. Propose that the detection of a sensory-motor mismatch between performed and observed movements may play the essential role in facilitating and modulating motor neuron excitability in a mirror-box-like paradigm. The authors also impose that this is in line with neuroimaging findings revealing the activation of cortical areas typically involved in detecting sensory-motor conflicts during the standard mirror-box paradigm.

That knowledge of an individual's preferred learning style, whether it be visual feedback, without feedback (e.g. kinaesthetic) or auditory feedback, can be a helpful tool in determining how to provide the appropriate feedback during motor learning and performance in order to accomplish and effect the execution of a task and also to determine the quality of motor performance in relation to the individual's preferred learning style [4]. Hence our purpose for outlining each subject preferred learning style in this study and correlate it to each subjects motor performance.

The purpose of this study is to determine the effects on peak grip force with the use of visual feedback, without feedback, and visual conflicted feedback, using a hand held dynamometer. Our first hypothesis is that among given feedback conditions in our study, visual feedback would result in greatest peak grip force. Second hypothesis is that visual learning preference will have correlation to the visual feedback and/or visual conflicted feedback.

CASE PRESENTATION

Recruitment

Recruitment of participants for the study occurred from March 11th to April 17th 2015 *via* a poster on NYU's Department of Physical Therapy announcing board, and e-mailed to the department's students (age 21-35). Written information about the study was delivered by email, or phone call, see Appendix A.

Subjects

Sixteen subjects were recruited and 10 met the inclusion criteria (five males, five females) and agreed to participate in the study. Subjects had to be non-smokers, right handed, healthy individuals, speak the English language, no experience with hand dynamometer testing, and no medication that could affect the hand grip function. The exclusion criteria were skin condition on the hands, diabetes, history of systemic disorders in the hands, neuropathy, surgery in hands, scar tissue on the hands, blindness, glaucoma, cataracts, and history of fracture in upper extremity. Three subjects were excluded due to left handedness (one), and history of old fractures (two). Thus, we collected data from thirteen subjects. However, data from three subjects were not included in data analysis due to subjects' inability to follow instructions to perform the grip strength test properly. Table 1 shows number of subjects, subjects' age (y), height (cm), weight (kg), cross sectional length of the Thenar muscle belly (left and right), lever arm (left and right), hand size level, and visual learning preference score. The study was conducted at New York University Department of Physical Therapy under the supervision of Professor Wen Ling.

Group (n)	Age (yr.)	Height (cm.)	Weight (Kg.)	Cross sectional length of Thenar Belly (inch)	Lever arm (inch)	Hand size			Visual learning preference score
						1	2	3	
Female (n=5)	26.4 (4.4)	168.7 (5.8)	70.0 (16.1)	1.6 (0.2)	10.1 (0.7)	1	3	1	6.4 (1.6)
Male (n=5)	27.2 (4.5)	174.9 (6.2)	70.8 (11.5)	1.8 (0.3)	10.8 (0.8)	3	2	-	7.6 (2.5)

Table 1: Means and standard deviations for various characteristics of subjects.

Instrumentation

Peak grip force for both hands was measured using the hand held dynamometer (microFET4). The reliability and validity is considered excellent (ICC ¼ 0.974_0.985). The technical error of measurement is small (17.8_22.7 Newtons). This instrument was connected to a computer with a corresponding software (The Blankenship System: TBS-2000, functional testing system). Another computer was used for visual conflicted feedback condition.

Protocol and testing procedure

The research team, consisting of six physical therapy graduate students, conducted the grip test with visual feedback, without feedback, and visual conflicted feedback. The same calibrated instrument was used for all the data collection. The greeter introduced the subjects to the study and the research team (see appendix B). After the greeting, the subjects were screened *via* the screener by a screening form and a learning style questionnaire. Post screening, the tester explained the procedure to the subjects before starting the test with a specific script, see appendix D.

The hand held grip testing procedure was as follows:

- Participants seated comfortably with their back supported.
- The tester adjusted handle size according to the subject's hand size. The shoulders adducted and neutrally externally rotated, elbows flexed at 90 degrees, forearm and wrist in neutral position.
- Subjects were instructed to grip the dynamometer smoothly for three seconds at maximal ability, which was regulated by a metronome and the software runner managing the software was responsible for tracking the duration of the contraction. Each trial started by the software runner would say "go", and the subject exerted maximum handgrip, by squeezing the handle of the testing device, thereby performing a maximum voluntary isometric contraction.
- When the software runner said, "switch", the tester moved the hand held dynamometer to the other hand and repeated the squeeze. One trial consisted of 12 contractions, starting with left hand and switching between left and right. The observer would make sure that the tester and subject obtained correct sitting position.
- The tester sat opposite to the subject.
- One tester was trained in the use of the dynamometer.
- Before testing, subjects were provided with a warm up trial, consisting of three contractions with each hand with the hand held dynamometer with resting time lasting two minutes at the end.
- The grip tests were performed under three different conditions; Subjects received condition sequence by a counterbalance blocks design, see Appendix E. Each condition included three trials for each hand. Two minutes resting was given between trials, and 5 minutes rest between each condition.
- The observer timed resting periods. For the visual feedback condition, the subjects were instructed to look at the computer screen and try to move the needle of the watch that appeared at the beginning of the test clock-wise, by squeezing the handle of the. Using the same protocol, the subjects performed the test without feedback condition; the subjects were instructed to focus on the tester's face while squeezing the hand. For the visual conflicted feedback, again the same protocol was, the subjects were instructed to focus on a picture that was displayed on a computer screen, while they squeezed the handle. All three conditions were tested in the same day.
- Verbal feedback was given to the subjects at the end of the each trial by the observer and tester. Testing lasted for one hour for each subject.
- Peak grip force was recorded in pounds, and registered by the software runner for further analysis.

Measurements

Baseline data collections started in March 26th 2015 and lasted throughout April 17th 2015, see Appendix C, and included the following: Screening form which covered each subject's demographic information, see Appendix C1. Learning style questionnaire which covered questions to determine each subject's preferred learning style, see Appendix C2.

Statistical analyses

Descriptive statistics (means and standard deviations) were used to describe the characteristics of each subject. Each trial measured 6 peak grip forces from both hands, which is 12 raw data in total. In order to analyze the data, we selected the only two out of three trials from each condition and dropped out two inconsistent data from each trial. We averaged 8 raw data from left and right hand of each feedback condition. We used repeated measure analysis of variance to investigate the effect of feedback conditions within subjects. We normalized peak force for visual feedback and visual conflicted condition by dividing peak force of visual feedback condition with peak force of without feedback condition, and by dividing peak force of visual conflicted condition with peak force of without feedback condition. Pearson correlation coefficient analysis was used to investigate the influence of visual learning preference to the normalized peak grip force in the conditions of visual feedback and visual conflicted feedback. Covariates included in the analysis were height, left and right lever arms, left and right cross section of thenar muscle belly. Differences were considered statistically significant at $p<0.05$. All analyses were done using SPSS version 22.0.

RESULTS

The average value of the peak grip force for the three feedback conditions were analyzed through repeated measure ANOVA design to determine whether one feedback condition was more effective on peak force from another feedback condition (Table 2).

Conditions	$\bar{x}$ (SD)		
Average Peak Grip Force (lbs)	Without feedback	Visual feedback	Visual conflicted feedback
	54.22 (4.0)	62.59 (3.9)	53.22 (3.9)

Table 2: The average peak grip force across feedback conditions mean.

The result revealed that there was a statistically significant difference in peak grip force across the three feedback conditions (F (2,19)=8.217, p=0.001). Between visual feedback condition and visual conflicted feedback showed statistically significant difference in the average peak grip force (p=0.001) while the difference on average peak grip force between visual feedback condition and without feedback condition was statistically significant (p=0.015). We found that when individuals were provided with visual feedback, they generated higher peak grip force than when they were provided with without feedback condition or visual conflicted feedback. Although without feedback condition showed higher peak grip force than conflicted feedback condition, there was no statistically significant difference between both conditions (Figure 1).

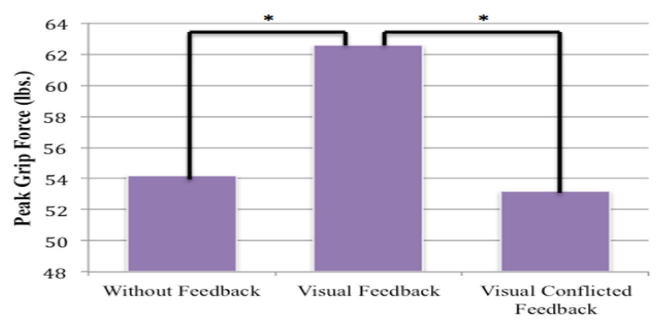

Figure 1: The average grip force across feedback. Note: * P<0.05

We investigated whether visual learning preference would relate to the peak grip force across the different feedback conditions. After normalizing the data, the result showed no statistically significant correlation between visual learning preference score and normalized visual feedback condition. Also the correlation between visual learning preference score and visual conflicted condition was not statistically significant. Furthermore, we excluded the influence of height, levers arms, cross sectional length of the thenar muscle belly, and the peak grip force since there was no statistically significantly correlation between them and peak grip force.

DISCUSSION

The purpose of this study was to determine the effects on peak grip force across three feedback methods; visual feedback, without feedback, and visual conflicted feedback, with the use of a hand held dynamometer.

Our hypothesis was that visual feedback would result in greatest peak grip force. Reviewing the previous literature on the availability of visual feedback and the impact that could occur to an individual being exposed to it varies [5]. A test case using a digital dynamometer resulted with in a statistically significant difference between grip strength scores in the visual feedback and no feedback test conditions overall.

Also, recorded isometric elbow flexor strength of 15 students with and without knowledge of results. Those subjects who received visual feedback in the form of a load cell gauge obtained strength scores significantly greater than those of subjects who did not receive any extrinsic or augmented feedback. On the other hand, used a hand held dynamometer connected to the Dexter computer system, which reproduced a Jamar dial on the screen and found a group of physically impaired elders to have a 1.02 kg stronger grip score with verbal feedback, but not with visual feedback. found no significant differences on the impact of visual or auditory feedback on grip strength under four test conditions: No feedback, auditory feedback; *via* the speed of audible clicks on a speaker that accelerated as strength score increased, visual feedback; *via* fluctuating needle on a 12 cm horizontal scale that moved toward the right as strength score increased. However, these studies were conducted with visual feedback that differs from the study done. And this current study.

According to the literature, visual feedback provided in the form of biofeedback can quantify the performance, such as force production [6-11]. Subject's voluntary movements can have a better control since the individuals are provided with the feedback that is measured electronically from their activities. Not only does the visual feedback give current information helping the individuals in self-correctness and self-improvement, but individuals may also gain the effect of motivation from available visual feedback.

According to our findings, when each subject was provided with visual feedback, they generated significant peak grip force rather than when each subject was provided with without feedback condition or visual conflicted feedback condition. Without feedback condition resulted in higher average peak grip force than conflicted feedback condition, however this difference was not statistically significant. This raises the question whether the statistically insignificance in the results may be due to the necessary alterations made in the way the conflicted visual feedback was provided when comparing with literature. It has long been known that focusing attention on coordinating one's movements while executing a motor skill can disrupt the performance of automated skills [12]. Self-focused attention can also have degrading effects on learning new motor skills. According to the theories and the findings in this study, using a conflicted visual feedback supports the results that subjects who were exposed to the conflicted visual feedback method degraded rather than improve their performance and peak grip force. In subsequent studies, demonstrated that performance and learning can be enhanced by directing the learner's attention away from his or her own movements and direct the attention to the effects these movements have on the environment. But the literature does not have any statistically significant results to support whether the conflicted visual feedback can increase the efficacy of motor performance.

If perhaps it is the type of learning required by the subject that determines whether or not extrinsic feedback will have a positive effect on motor performance. This supports our second hypothesis whether visual learning preference would have correlation to the visual feedback. The current study revealed no statistical significance in correlation between visual learning preference score in relation to the visual feedback condition [13-17]. Therefore, we cannot conclude if the visual preference as a learning style can affect peak grip force with providing visual feedback. This inconclusive finding may be due to the lack of sufficiency in the learning style questionnaire used in this study to evaluate the visual preference. Our questionnaire was inspired by the.

Due to unsustainability in the data, we were compelled to drop three subjects, which is equivalent to 23.08% of the sample size in this study. This raises the question whether this unsustainability is a motor control issue or whether it is a performance issue. In previous studies, suggested that one critical factor underlying the learning advantage, is the degree to which a specific attentional focus causes the performer to intervene or constrain the more natural coordination of their body movements [18]. External foci, which cause the participants to direct their attention to the effects of their movement and away from processes controlling their movements, seem to allow more automatic control processes to take over and result in enhanced performance and learning. With that said, these are all speculations, due to lack of literature on measuring the above mentioned factors.

The technological improvements in grip strength testing, and other measurements of impairment and limitations, are widely used in clinical settings in order to assess and evaluate peak grip force. However, the research studies about the use of different feedback conditions in assessing the peak grip force is not well established and lead to confusion among clinicians regarding what constitutes best practice [19]. In addition, the feasibility and acceptability of the most effective feedback in measuring grip strength in different healthcare settings is not clear. Clinicians and researchers should test grip strength consistently to identify the usage of a dynamometer, and the different availability of feedback [20]. Until more research is done, in which feedback conditions are considered the most effective for enhancing the hand grip strength, it would be appropriate for clinicians to use visual feedback in practice.

LIMITATIONS OF THE STUDY

The limitations of this study cannot be overlooked. Factors, such as small sample size that decreases the power of the study, and insufficient number of questions on the learning style questionnaire. Moreover, the sample was not normally distributed, which also lead to difficulty in finding significant relationships. Statistical tests require a larger sample size or normally distribution of the sample to ensure a representative distribution to which the results will be generalized or transferred. In addition, the way we provided the visual conflicted feedback was different than the way the literature described due to insufficient time and limited resource capabilities. Furthermore, there is a lack of data on the effect of visual conflicted feedback in peak grip force, which limits the scope of our analysis. Finally, we cannot ignore the fact that we apply our study only in healthy individuals, and we did not compare the results to individuals with hand function dysfunction and limitations.

CONCLUSION

The results of this study support the supposition that subjects generate higher peak grip force when provided with visual feedback. This study has achieved statistically significant difference between visual feedback and without feedback, also a statistically significant difference between the visual feedback and visual conflicted feedback. However, the correlation from the learning preference questionnaire and visual feedback was not reflected and supported by the fact that visual feedback works better and has an enhancing impact on performance of the visual learner.

Further research should be done to gain knowledge on the significance of the methodology used in a visual conflicted feedback and sufficient questionnaire, for investigating the learning preference.

REFERENCES

1. Desrosiers J, Rochette A, Boutin C. Movement Science: Impact of immediate visual feedback and verbal encouragement on grip strength. Scand J Occup Ther. 1998;5(1):25-9.
2. Bohannon RW. Test-retest reliability of the MicroFET 4 hand-grip dynamometer. Physiother Theory Pract. 2006; 22(4):219-21.
3. Calvo-Merino B, Grèzes J, Glaser DE, Passingham RE, Haggard P. Seeing or doing? Influence of visual and motor familiarity in action observation. Curr Biol. 2006;16(19):1905-10.
4. Jung MC, Hallbeck MS. Quantification of the effects of instruction type, verbal encouragement, and visual feedback on static and peak handgrip strength. Int J In Ergon. 2004;34(5):367-74.
5. Liu T, Jensen JL. Effectiveness of auditory and visual sensory feedback for children when learning a continuous motor task. Percept Mot Skills. 2009;109(3):804-16.
6. Maciaszek J, Borawska S, Wojcikiewicz J. Influence of posturographic platform biofeedback training on the dynamic balance of adult stroke patients. J Stroke Cerebrovasc Dis. 2014;23(6): 1269-74.
7. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S. Grip and pinch strength: Normative data for adults. Arch Phys Med Rehabil. 1985;66(2):69-74.
8. Nicolay CW, Walker AL. Grip strength and endurance: Influences of anthropometric variation, hand dominance, and gender. Int J Ind Ergon. 2005;35(7):605-18.
9. Wallström Å, Nordenskiold U. Assessing hand grip endurance with repetitive maximal isometric contractions. J Hand Ther. 2001;14(4): 279-85.

10. Olsson CJ, Jonsson B, Larsson A, Nyberg L. Motor representations and practice affect brain systems underlying imagery: An fMRI study of internal imagery in novices and active high jumpers. Open Neuroimaging J. 2008;2.
11. Olsson CJ, Nyberg L. Motor imagery: If you can't do it, you won't think it. Scand J Med Sci Sports. 2010;20(5):711-15.
12. Pierson WR, Rasch PJ. Effect of knowledge of results on isometric strength scores. Res Quart Am Assoc Health. 1964;35(3):313-15.
13. Senna I, Russo C, Parise CV, Ferrario I, Bolognini N. Altered visual feedback modulates cortical excitability in a mirror-box-like paradigm. Exp Brain Res. 2015;233(6):1921-29.
14. Shumway-Cook A, Horak FB. Assessing the influence of sensory interaction on balance: Suggestion from the field. Phys Ther. 1986;66(10):1548-50.
15. Stinear CM, Byblow WD, Steyvers M, Levin O, Swinnen SP. Kinesthetic, but not visual, motor imagery modulates corticomotor excitability. Expl Brain Res. 2006;168(1):157-64.
16. Weinstock-Zlotnick G, Bear-Lehman J, Yu TY. A test case: Does the availability of visual feedback impact grip strength scores when using a digital dynamometer? J Hand Ther. 2011;24(3):266-76.
17. Weiss-Lambrou R, Dutil E. The effect of differing feedback conditions on grip strength: A pilot study. Occup Ther J Res. 1986;6(2):93-103.
18. Wulf G, Hob M, Prinz W. Instructions for motor learning: Differential effects of internal versus external focus of attention. J Mot Behav. 1998;30(2):169-79.
19. Wulf G, Prinz W. Directing attention to movement effects enhances learning: A review. Psychonomic Bulletin Rev. 2001;8(4): 648-60.
20. Wulf G, Shea C, Park JH. Attention and motor performance: Preferences for and advantages of an external focus. Res Q Exerc Sport. 2001;72(4):335-44.