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NORTHERN ILLINOIS UNIVERSITY

Tactile cues: relations between the afferent and efferent nervous system and its effect on resistance training.

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Requirements of the Baccalaureate Degree**

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Kinesiology

By

Patrick O'Connell

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Capstone Approval Page

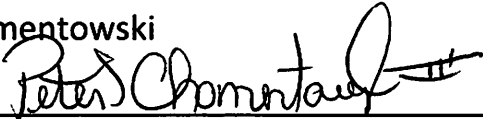
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Tactile cues: relations between the afferent and efferent nervous system and its effect on resistance training.

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ABSTRACT (100-200 WORDS):

Tactile cues: relations between the afferent and efferent nervous system and its effect on resistance training.

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Abstract:

Objective: Resistance training has been shown to have positive effects on increasing muscle mass and strength in healthy individuals. Athletes of all different backgrounds are always seeking new ways to maximize strength gains to maximize performance. The purpose of this study was to examine the effects of tactile cues on individuals progressing through a six-week strength training program. Participants: Male college students ($n = 18$) aged (21 ± 1.46) participated in an experiment testing the effect of lower extremity tactile cues and muscular strength. Outcome measure: Anthropometric variables were recorded: age, height, body weight, body mass index, body fat percentage and fat free mass. Muscle strength was assessed by a 1-repetition maximal leg extension test (1 RM) using a standard leg extension machine. Subjects were then randomized to either the control or the experimental tactile cues group. Both groups were asked to perform knee extensions twice a week on nonconsecutive days during their own prescribed strength training program. Each subject was instructed to perform a predetermined amount of repetitions that corresponded with 50% of their 1-RM test. During the strength training the experimental group performed detailed tactile cues provided by the PI when they were performing their weekly leg extension exercises. Post 1-RM was assessed the following sixth week of strength training.

Results: Height was found to be statistically different between the control and experimental groups ($p < .05$). No significance was observed for the other anthropometric variables ($p > .05$). It was observed that the experimental group displayed a statistically significant difference in mean strength following the six weeks of tactile cues ($p = .022$) compared to the control group.

Conclusion: This study indicates that prescribed tactile cues for a leg extension exercise can have a significant effect on increasing muscular strength following six weeks on implementation during a strength training program.

Key words: tactile cues, resistance training, strength

Introduction:

Resistance training is a key component that an athlete will utilize during training to increase their performance output. Regardless of sport athletes can benefit from the physiological changes of resistance training. Which include increase in muscular strength, lean muscle mass and power output. (12).

Muscular Strength is defined as maximal force that a muscle or muscle group can generate. Power is the explosive aspect of strength defined as strength multiplied by distance traveled. (1,

2) An increase in strength or power is more useful in some sports than others. Sports like weightlifting, football, and rugby all benefit greatly from improved strength and power. Athletes participate in resistance training programs for several reasons and these can include: to increase muscle mass, strength, power, and endurance or to decrease body fat composition or injuries related to high intensity training programs.

Healthy individuals starting a resistance training program will demonstrate the greatest adaptations during the first six months of training due to neuromuscular adaptations. These adaptations are due to the improvements in motor unit recruitment and the rate coding of firing action potentials (3). The peripheral nervous system is divided into the afferent and efferent nervous systems. The afferent receives information from outside environmental stimulus and transmits the signal to the CNS for a response. The efferent system transmits the CNS generated response to either the somatic or autonomic peripheral nervous system to execute a specific action. (4) If one used a limb to give an afferent stimulation to a contracting muscle would it have any effect on the efferent response?

During early stages of resistance training the adaptations of the nervous system and muscular system work in conjunction with each other to provide a maximal response to a new stimulus. A question can be asked if athletes are training as effectively as they could be, and could tactile cueing enhance strength in individuals with the proper usage.

In physical therapy many post-operative patients are given tactile cues as part of their recovery. This is to reinforce proper muscle recruitment while performing a designated movement pattern. Many patients need assistance in learning how to perform a new movement pattern and recruit the needed muscles to complete the task. An example could be learning a common leg extension movement properly after having a knee replaced with an artificial joint (9).

Considering these unique relations, the ability to utilize tactile cues can help individuals with early motor unit recruitment, developing muscular strength, and learning a new movement pattern. More information should be gathered on the relationship between tactile cues and how using the nervous system can have an impact on overall strength gains for individuals and seasoned athletes. Tactile cues could be used to assist athletes with becoming stronger while developing their movement pattern. This could lead to athletes training more efficiently and creating an edge for their overall performance.

With the relationships between the afferent, efferent nervous systems and the muscular system, we investigated the effects of tactile cues on strength training for seasoned weightlifters. It is hypothesized that when putting seasoned weightlifters on a program with the goal of strength gain they will increase their strength. In addition, it is hypothesized that seasoned athletes doing the same program using tactile cues on the muscle tested during training will see a greater net increase in strength than seasoned athletes that do not use tactile cues.

A defensive team in football could have that much more strength to block the opposing team, and an Olympic level weightlifter could get the edge on his competition.

Methods:

Participants

Eighteen subjects age 19-24 years were recruited from the general student body in the kinesiology department at Northern Illinois University. Subjects were recruited from classes in the kinesiology department with permission of the instructors. Participation in the study was limited and females and males that were not resistance trained were excluded. The American College of Sports Medicine defines being resistance trained as doing resistance training at least three times a week consistently for at least the last six months. Subjects interested and qualified filled out a health history form and a PAR-Q to demonstrate that nothing else prevented subjects from participating in the study. Institutional Review Board approval was obtained for the proposed study and informed consent signed by each participant prior to participation.

Preliminary Screening

Following the health history, PAR-Q, and informed consent, the subject's anthropometric measurements were taken. Anthropometric data including height, weight, fat mass and fat free mass was collected in addition to resting blood pressure values utilizing a standard blood pressure cuff. Body composition was taken in light clothes and bare feet using an InBody520 body composition analyzer (Cerritos, CA, 2011). Participants were asked to abstain from heavy exercise prior to 24 hours to their respected initial test as well as to refrain from eating two hours prior, and to void their bowels before the test. Subjects were instructed to bring appropriate attire to the test, exercise shorts were heavily encouraged. Subjects were randomly assigned to a group.

Pre-Exercise trials

Upon arrival at the exercise testing facility, the testing procedures were explained, and subjects were asked to communicate their training experience using leg extension equipment. They were instructed that on how to perform a one-leg machine extension with their dominant leg. 1RM strength was conducted using a concentric contraction of the quadriceps muscles and this was administered on a Magnum Fitness E series leg extension (Milwaukee, WI). Subjects were asked to perform three warm up sets that consisted of 5-10 repetitions. Between each set subjects were instructed to complete a one-minute active recovery that consisted of walking around the testing facilities. Weight was increased after each warm-up set to help facilitate blood flow to the working muscles.

Initial Exercise Trial

After completing the third warm up set subjects started the official 1 repetition max test. (1RM). Subjects were asked to complete one repetition using their full explosive power and a completed repetition was defined as a complete lower leg extension from 90° to 180°. If the subject completed the repetition they were asked to perform a walking active recovery of 2-4 minutes before the next attempt. For the next attempt the weight would be increased weight after the 2-4-minute rest period. If a repetition was not completed the weight was then lowered halfway between the failed weight and the last completed weight. Subjects would then attempt a 1RM

with that weight. If the subjects succeeded that was his 1RM, if failed the last completed weight was his 1RM. Subjects were given two attempts to complete each weight attempt.

Strength training protocol

After completing the initial exercise trial subjects were informed which group they had been randomized into: control or variable. Subjects were asked to continue their current weight training program for six weeks program with the goal of increasing their muscle strength. Following the six weeks the subjects were retested for their leg extension 1RM. During the six weeks each subject was responsible for training on his own and every Thursday, the investigators would contact the subjects via email for training updates and to provide supportive feedback on the training protocol. The protocol was near identical between the control and variable. The only difference was that the variable group would be using tactile cues during their resistant training over the six weeks. The tactile cues used by the variable group was that of a touch with both hands. Subjects in the variable group were asked to hold their quadricep during the entire phase of the contraction. Subjects were asked to use place the corresponding hand slightly inferior to the hip. Subjects were asked to use tactile cues in the form of touch with their other hand just superior of the knee. (example: subject using right leg would place right hand slightly inferior to hip joint and left hand slightly superior to knee joint.) Subjects in the variable group were shown how to preform the tactile cues after the initial visit. Subjects in the variable group were reminded with every update email to use the tactile cues along with instructions in the event they had forgotten. Subjects were also encouraged to ask for clarification if confused during initial visit and during every update email.

At each exercise session subjects would perform warm-ups to begin the session. The given warm up consisted of two sets of five repetitions with a 1-minute rest in-between sets. The weight for the warm up sets was at 50% of their initial 1RM. Once the warm up was finished each subject was told to complete 3 sets of 10 repetitions two times a week on nonconsecutive days with a two-minute rest interval. The weight for each subject was a set percentage of each subjects initial 1RM. Weeks 1, 2, and 3 were 80% of the subject's 1RM, while weeks 4, 5, and 6 were 83%. Each subject was supplied the weight in pounds they should be using to avoid the subject using an incorrect weight. In the event a subject completed his sets with ease or were unable to complete all the sets and repetitions he was informed to communicate to the administrators. If a subject completed the sets and repetitions with ease the weight was increased by 5 pounds and if subjects were unable to complete the assigned weight, weight was decreased by 5 pounds. If subjects were unable to complete the given sets and reps, they were also informed to attempt the same weight the next day they would perform the exercise.

Post Intervention Testing

After the subjects completed their six-week training they were asked to return to the exercise testing facilities for their strength post-test 1RM. The subject's anthropometric measurements were taken again in light clothes and bare feet using an Inbody520 body composition analyzer. The post test was completely identical to the initial test and investigators were blind from the subject's pretest 1RM values. Once completed subjects were thanked for participation and were then given their 1RM numbers of both pre and post evaluation to see if they improved.

Statistical Analysis

Demographic data, independent variable, and dependent variables were recorded in Excel (Microsoft Corporation, Redmond, WA) and then analyzed using SPSS Statistics v.21 (SPSS, Inc., Chicago, IL). An alpha level of $p \leq 0.05$ was considered statistically significant for all comparisons. One-way (ANOVA) was performed to determine changes in body weight over time. Changes in each subject's 1 rep maximum were recorded by the administrators and analyzed using a repeated measure analysis of variance (ANOVA) between subjects on the two groups: control and variable.

Results:

Seventeen subjects completed the study and individual demographics (mean \pm standard deviation) are displayed in Table 1. Subjects anthropometric measures were recorded during both visits for deviation during the duration of the protocol. One-way repeated measures ANOVA was conducted to determine whether there was a significant difference for baseline measures. There were no significant differences for age, weight and body fat percentage between the groups, see table 1. There was a statistically significant difference for height between the two groups at baseline ($p = .008$) Data was normally distributed for both groups during both trials.

T-test was conducted to explore changes in weight and body fat percentage for subjects over the course of the training. No significant differences were found; however, a statistically significance difference was observed for fat percentage, see table 2.

A T-Test for strength was conducted examining the changes between the groups for weight and fat percentage. (see Table 3). No significant difference was observed for weight or body fat percent between the groups ($p < .05$). The significance displayed in body fat percent change for all subjects disappeared once the subjects were divided in their respected groups.

Strength for all subjects except two increased from pretest to posttest and values were statistically significant, see table 4. When examined by groups it was observed that the tactile cue group displayed a statistically significant increase in 1RM while the control group had no significant changes between pre and posttest.

Table 1. (baseline Antropometric Measures)

	Control	Variable	Significance
Age	22.44 \pm .88	20.66 \pm 1.4	.06
Height	171.33 \pm 6.28	181.22 \pm 7.52*	.008
Weight	163.44 \pm 23.25	188.77 \pm 35.72	.094
Fat Percentage	17.56 \pm 9.68	16.11 \pm 8.31	.074

*Statistically Significant at alpha level of $p \leq 0.05$

Table 2 Changes in baseline measures for weight and body fat percentage

	Pre	Post	p value
Weight	179.65±29.15	179.53±29.16	.886
Fat percent	17.0±9.03	15.5±9.32*	.029

Note: *Statistically Significant at alpha level $p \leq 0.05$; all values mean±SD

Table 3: Changes in weight and body fat percentage for intervention groups.

		Pre	Post	p value
Control	Weight	169.38±16	169.66±13.97	.812
Variable		188.78±35.72	188.33±36.68	.738
Control	Fat percent	18±3.63	16.63±9.65	.204
Variable		16.11±8.31	14.56±9.48	.097

Note: all values mean±SD.

Table 4: Strength changes for subjects

	Pre-test	Post-test	p value
All	185.29±39.66	208.23±49.71*	.004
Control	181.25±16.42	203.75±45.65	.101
Variable	188.88±53.66	212.22±55.52*	.022

Note: *Statistically Significant at alpha level of $p \leq 0.05$; all values mean±SD.

Discussion:

The purpose of this study was to examine the effects tactile cues had on muscle recruitment and strength gain during the span of several weeks. The findings of the current study suggest that tactile cues incorporated into a strength training program may be more effective than training without the use of tactile cues. Studies have shown that the used of tactile sensory inputs improve stability it could very well effect strength as well. (13) More studies on the relation between tactile cues and strength will need to be conducted.

In the current study, tactile cues performed with a strength-based exercise protocol did provide a statistical difference comparatively. While both groups on average did experience strength gains similarly the variable group had higher results. These findings supported our hypothesis that tactile cues would provide significant strength gains in a six-week exercise program for seasoned lifters.

Tactile cueing in the form of holding a contracting muscle is a risk-free addition to exercises that allow it, such as bicep curls, leg press and overhead triceps extensions. Compound exercises such as heavy bench press or squats however, would not allow such access. Research examining

the effects of tactile cueing on seasoned weightlifters is limited. However tactile cues are used often in physical therapy settings. (9) Their main use is with post-op patients who need to learn how to properly recruit certain muscles. Therefore, the current study suggests that the use of tactile cues as a regular part of an exercise routine could promote greater strength gains. The thought is that the cue will promote more motor units to fire. Neuromuscular Electrical Stimulation is another way to stimulate a muscle and recruit more motor units. Physical therapists use NMESs for post stroke patients. (10,11) Because this is used in the clinical field we can concur that with proper stimulation more motor units can be contracted. Would self-cueing be a proper stimulation?

The results of this study have large implications. Once weightlifters are considered seasoned the growth of their muscular and strength gains is lower than when started. During the first six months individuals who start resistance training will see incredible gains. These initial gains are mainly adaptations of the nervous system. After the first six months, improvements are still made but at a much slower rate. (7) Giving oneself a tactile cue in the form of a touch is easily accomplished and requires no teaching or preparation. In the field of exercise physiology, 7 weeks is widely considered a short time period to see neuromuscular adaptations. Considering that this study used resistance trained subjects as well as what is considered a short time window to see physiological changes tactile cues could have a large impact on the future of resistance training. It would be interesting to conduct this study with more subjects over a longer duration. It could also be beneficial to test the use of tactile cues on a female population and a nonresistance trained population.

There were several limitations to this study. Subjects were not witnessed performing the protocol. Because of this it is uncertain whether subjects completed it to the specificity to which they were told. Subjects might have forgotten to train both days a week or train with an incorrect weight. Two subjects in the study, one from each group, had a final 1RM test that was lower than their original. Completing a strength-based program for six weeks should have caused their 1RMs to increase or stay stagnant at the least. (8) It is presumed that the subjects that received a decline in strength did not participate in the program. Another subject who had a decline in his 1RM donated plasma an hour prior to taking the final test. This subject communicated this to the administrators after completion of the test. Dietary intake was not controlled for during the study. Dietary intake prior to both exercise sessions was addressed before each test. Diet could influence strength gained over eight weeks as well as higher performance. (5) The use of ergogenic were also not recorded. Subjects might have been taking one or several ergogenic performance boosters. Ergogenic influence has been shown to effect strength gains. (6)

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