2016

Electromyographic Analysis of Hip Muscle Activity Comparing Maximal Voluntary Contraction to Manual Muscle Test Grades

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A Scholarly Project Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine and Health Sciences

University of North Dakota

in partial fulfillment of the requirements for the degree of

Doctor of Physical Therapy

Grand Forks, North Dakota
May, 2016

This Scholarly Project, submitted by Ty Bommersbach, Anthony Charbonneau, Holly Koch, and Braidy Solie in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Graduate School Advisor)

(Chairperson, Physical Therapy)

PERMISSION

Title Electromyographic Analysis of Hip Muscle Activity Comparing Maximal Voluntary Contraction to Manual Muscle Test Grades

Department Physical Therapy

Degree Doctor of Physical Therapy

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ACKNOWLEDGEMENTS

The authors would like to extend their gratitude to Dr. Thomas Mohr for designing the study protocol and for assisting with technical and research support. We also thank the test subjects who volunteered their time to participate in the study. In addition, we thank Dr. Renee Mabey for assisting in the development of this study topic and the University of North Dakota Department of Physical Therapy for supplying the materials to complete the study.

ABSTRACT

Introduction: The purpose of this study was to investigate the relationship between muscle activity during three manual muscle tests (MMT) and muscle activity during a maximal voluntary contraction (MVC) of the same muscle. **Subjects**: Eleven female subjects voluntarily participated in this study. All participants were physical therapy students under the age of 30, nonpregnant, and without recent history of musculoskeletal injury. **Methods:** Electromyographic (EMG) data was collected by placing surface electrodes over each participant's right tensor fasciae latae (TFL) and gluteus medius (GM) muscle. The EMG data from each muscle was transmitted by Noraxon† TeleMyo2400 G2 telemetry to a computer equipped with MyoResearch XP 1.07 software. EMG data was collected while each participant performed a MVC and a Normal (5), Fair (3) , and Poor (2) Grade MMT test for each muscle, respectively. **Results**: EMG data analysis produced an average percentage of MVC for MMT of GM and TFL using Grades 5, 3, and 2 as follows: 91.7%; 32.3%; 20.7%. **Conclusion:** This study shows the percentage of MVC EMG activity elicited by MMT of Grades 5, 3, and 2 for TFL and GM. These percentages could possibly be used by clinicians as an inferred benchmark of muscle activity elicited by patients achieving these MMT scores; referenced as a percentage of MVC in normal functioning muscle.

CHAPTER I

INTRODUCTION

Manual muscle testing (MMT), as used by physical therapists, dates back to 1912[1] as a way to test the strength of patients with "Infantile Paralysis." The MMT methods used today largely follow the procedures described by Henry and Florence Kendall[2] to test strength changes in patients with poliomyelitis. There have been several recent publications reviewing the validity and reliability of MMT. Aitkens et al[3] found significant correlations between MMT and isometric strength, however the correlations between the two were not high enough to predict isometric strength from MMT scores. Other recent studies have also found MMT to be a reliable and valid method for measuring strength changes in patients with neuromuscular dysfunction.[4-7] Although MMT appears to be valid and reliable for measuring changes in muscle strength there is little evidence to suggest that MMT results correlate to any functional activity such as walking. Therefore, the purpose of this study was to investigate the relationship between muscle activity recorded during three different MMT tests with the muscle activity recorded during a MVC of that same muscle.

CHAPTER II

SUBJECTS

Eleven female subjects participated in this study. The volunteers selected were between 20 and 30 years of age, and were current physical therapy students. The subjects were recruited through a verbal invitation to participate as well as a sign-up sheet in the University of North Dakota Physical Therapy department. In an effort to reduce testing variability, no male subjects were recruited. All selected participants were current physical therapy students from the University of North Dakota who were healthy and had no recent history of injury prior to testing (Age 23.63 ± 0.81 years; weight 65.6 ± 8.7 kilograms; height 155.87 ± 31.21 centimeters). Before testing, participants were given a full explanation of the research study and its purpose, as well as verbally consented to the study and signed a consent form approved by the Institutional Review Board to comply with the ethical principles of the Declaration of Helsinki (1975, revised 1983). Subject characteristics are given in Table 1.

Table 1. Subject Characteristics

AGE (yrs)	23	25	24	23	25	24	23	23	23	24	23
HEIGHT (cm)	170	165	163	172	64	163	153	157	159	170	175
WEIGHT (kg)	88	58	68.49	63.05	58.3	68.04	58.51	63.96	58.06	68.04	68.95

CHAPTER III

METHODS

Procedure

Muscle bellies of the right TFL and GM along with the right anterior superior iliac spine (ASIS), were identified following the guidelines published by the surface EMG for non-invasive assessment of muscles (SENIAM) project.[8] Next, the TFL, GM, and ASIS landmarks were lightly abraded using 3M® sandpaper followed by cleaning of the site with isopropyl alcohol to reduce skin impedance. Wireless, self-adhesive EMG pads were placed over the muscle bellies at a distance of 4 cm from the centers of the pads; the ground EMG was placed over the right ASIS. The placement of the electrodes was in accordance with standardized lead positions.[8,9]

Manual muscle testing protocols for the TFL and GM, as described by Reese,[10] were used for the research study. Manual muscle testing Grades 5, 3, and 2 were placed on index cards for random selection by the participants to prevent an ordering effect from occurring. Participants then selected an index card and positioned themselves under the direction of research staff on a plinth. The EMG activity was recorded using a Noraxon† TeleMyo2400 G2 telemetry unit with a sampling rate of 1 kHz, which was transmitted to a TeloMyo PC interface card connected to a laptop computer. The digitized information was stored on a laptop computer. Data analysis was performed using the MyoResearch XP 1.07 software. EMG activity was recorded by placing Blue Sensor (model M-00-S) surface electrodes on the skin over each of the muscles under study. Wireless EMG data were collected for a duration of five seconds per testing position.

One researcher ran the computer program collecting the data while another carried out the MMT protocols. Random MMT was continued in this manner until data was collected for each testing position for each participant. At the conclusion of random

MMT, EMG data for MVC was collected for each participant. This was accomplished in the same manner as Grade 5 MMT with the addition of using a Velcro® strap fastened to the plinth as the resisting force rather than the researcher's manual resistance.

Data analysis was accomplished using the Noraxon MyoResearch software. The EMG data was normalized based on the muscle activity of each subject recorded during the elicitation of a MVC. The EMG data from the MMT trials were expressed as percentages of the MVC.

CHAPTER IV

RESULTS

Results from the comparison of EMG data collected during MMT to EMG data for each muscles' associated MVC is displayed as a percentage of MVC (Figure 1).

EMG data yielded an average percentage of MVC for MMT of GM and TFL using Grades 5, 3, and 2 as follows: 91.7%; 32.3%; 20.7%. Additionally, collected data revealed that the TFL activity was 24.3% of MVC with a Grade 2 MMT, 30.2% of MVC with a Grade 3 MMT, and 93.1% of MVC with a Grade 5 MMT. The GM EMG data shows activity at 17.0% of MVC with a Grade 2 MMT, 34.4% of MVC with a Grade 3 MMT, and 90.3% of MVC with a Grade 5 MMT.

There does not appear to be a linear relationship between a MMT Grades. Although we found little difference in EMG activity between Grades of 2 and 3, there was a sharp difference between Grades 3 and 5.

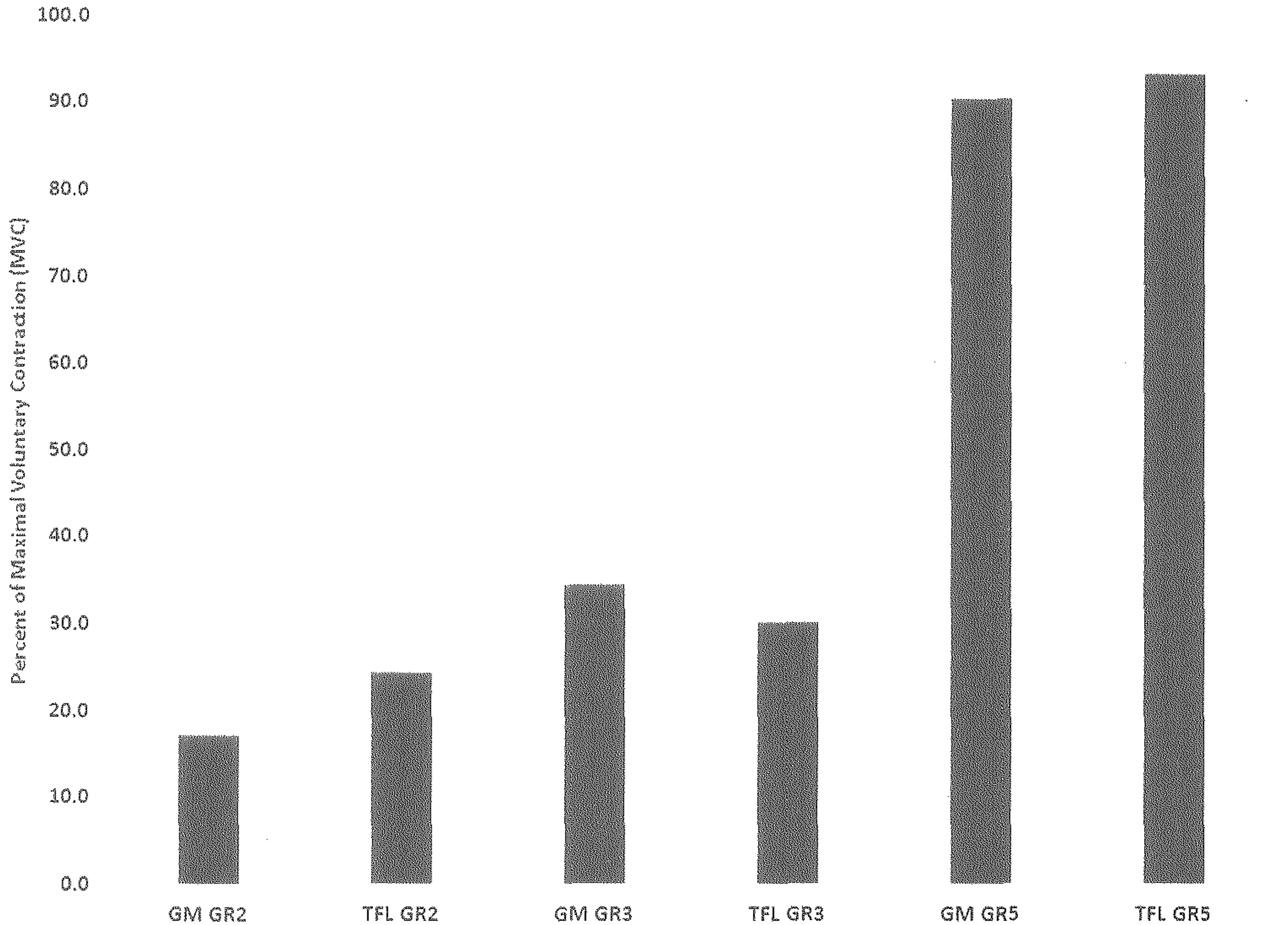

Figure 1. Comparison of the Percentage of Maximal Voluntary Contraction (MVC) of Tensor Fascia Latae (TFL) and Gluteus Medius (GM) Muscle Activity During Grades 2, 3, & 5 of a Manual Muscle Test (MMT).

CHAPTER V

DISCUSSION

The aim of this present study was to study the amount of muscle activity required by the TFL and GM to achieve a Grade 5, Grade 3, and Grade 2 MMT rating. By collecting EMG data from MVCs to use as a reference of each participant's maximal achievable muscle activity, we were able to record an average percentage of maximal muscle activity for each grade of MMT. In the future, these percentages could possibly be used by clinicians to infer the approximate amount of normal muscle activity required to achieve a MMT score.

Recent literature has suggested that a manual resistance "break" test (in which the subject is asked to resist the tester's gradually increasing pressure) may be able to evaluate a muscle's ability to resist gradual pressure increases, which tests different aspects of neuromuscular control than tests against fixed resistances.[5]

In this study pressure was not increased to the point of a break and did not satisfy the criteria of a break test, but manual resistance for Grade 5 muscle testing was utilized. Our results did show that a Grade 5 test does produce muscle activity very close to a MVC. This might be expected since we used a fixed strap to apply resistance for the MVC and relied on the strength of the "tester" to apply resistance for a Grade 5 test. A Grade 5 will only yield muscle force equivalent to the strength of the person applying the resistance during the MMT.

This testing technique may be considered a more arbitrary measure of force compared to those measures that have more predetermined parameters for Grade 5 testing, such as dynamometry. However, the goal of this study was to replicate the traditional method of MMT as performed by clinicians.

CHAPTER VI

CONCLUSIONS

The results of this study showed that the three MMT grades do not appear to be linear relative to the numbering system used. However, a Grade 5 test produced muscle activity which approaches a MVC.

Future studies could examine the percentage of MVC required to perform everyday functional activities such as bed mobility, transfers, ambulation, and stair climbing. Having a better understanding of the minimal muscle grades required to complete specific activities of daily living (ADLs) would prove useful for clinicians in assigning appropriate goals for their patients.

A limiting factor of this study is that all subjects were healthy individuals of a similar demographic without comorbidities or hip pathology. Further studies may look at muscle activity in male and female populations of varying demographic and health backgrounds. It is also important to note that Grade 5 MMT does not have a standardized level of resistive force which may produce variances in inter-rater scoring.

APPENDIX

Table 2: MMT Average Percentage of MVC

Muscle	Grade 2	Grade 3	Grade 5
Tensor Fasciae Latae	24.3%	30.2%	93.1%
Gluteus Medius	17.0%	34.4%	90.3%

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