FORCE MATCHING SENSE: AN IPSILATERAL SHOULDER STUDY INVESTIGATING THE EFFECT OF TORQUE AND ELEVATION ANGLE

by

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A THESIS

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and the Robert D. Clark Honors College
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Bachelor of Science

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Katya Trousset for the degree of Bachelor of Science
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Title: Force Matching Sense: An Ipsilateral Shoulder Study Investigating the Effect of Torque and Elevation Angle

Approved: ______________________________

Andrew Karduna

Force matching sense (FMS), or the ability to reproduce a desired force one or more times, is one of three subdivisions that define proprioception. Unlike the other two, joint position sense (JPS) and kinesthesia, FMS is not associated with joint motion (Riemann & Lephart, 2002a). Previous research has found that JPS becomes more accurate as shoulder elevation and external load increases (D. Suprak, Osternig, & Karduna, 2005). The goal of the present study was to investigate how torque and shoulder abduction angle contribute to accuracy of FMS in an ipsilateral remembered force matching task. FMS was tested on the dominant arm of 12 subjects (6 males, 6 females) at three angles (50, 70, and 90 degrees of elevation in the scapular plane), and at 20, 40, and 60 percent above subject baseline torque. It was found that there was no significant change in error due to abduction angle ($p > 0.05$), but force reproduction error decreased as torque load increased ($p < 0.05$). From these findings, it appears that FMS does not follow the same pattern as JPS when reproducing a target at different angles, suggesting that these two components must be considered separately when assessing FMS proprioception.

Acknowledgements

I would like to give a special thanks to Andrew Karduna for allowing me the opportunity to work in his lab over the years. Not only for the opportunity, but for his extensive patience and advice that he has given me while pursuing this project. I would also like to thank David Phillips, for his unrelenting humor, his willingness to teach, and his excellent programming skills that made this experiment possible.

I am also sincerely grateful for all other members in the Orthopedic Biomechanics lab that have shared their time and knowledge with me along the way.

Table of Contents

List of Figures

List of Tables

Introduction

Proprioception allows the body to deliver afferent information from its periphery to the central nervous system (CNS) in order to maintain postural status, joint position sense, and its overall position in space. Conscious proprioceptive senses can be considered in three subdivisions: kinesthesia, joint position sense (JPS), and sense of resistance, or force (Riemann & Lephart, 2002a).

Force matching sense, or the ability to reproduce a desired force one or more times, has been thought to be possible due to the afferent feedback from Golgi tendon organs and cutaneous receptors in combination with feed-forward information from the CNS that is referred to as “sense of effort.” Joint position sense is referred to as the integration of proprioceptive information that can be used to reproduce a desired joint position in space without receiving visual feedback (Riemann & Lephart, 2002b).

By combining these two senses, it is possible to conduct every day biomechanical tasks like walking, running, or any combined fine motor tasks. This study looks at how these systems interact, and if these systems operate independently, or together. It investigates force-matching sense (FMS), and specifically how different shoulder abduction angles and torque level may affect accuracy in force reproducibility.

Prior research has shown that JPS improves similarly between right and left arms (King, Harding & Karduna, 2013) with shoulder elevation and external load (D. N. Suprak, Osternig, van Donkelaar & Karduna, 2007; D. Suprak, Osternig & Karduna, 2005), but to the best of our knowledge, sense of effort has not been investigated at the shoulder joint. It was hypothesized that FMS would increase in accuracy when at higher elevation angles and torque loads.

The present study aims to examine the differences, if any, between ipsilateral force matching production at different shoulder abduction angles and different torque levels.

Background & Literature Review

Proprioception

Riemann & Lephart (2002) have explained the components of proprioception and its contributions to functional joint stability, and provide most of the background information for this study. Proprioception, or awareness of the body in space, is made possible by the afferent information from peripheral areas of the body that is integrated in a way that makes postural control, joint stability, and other conscious sensations possible. The sources of these proprioceptive inputs are the mechanoreceptors primarily found in muscle, tendon, ligament, and the joint capsule. There are 4 main receptors found within ligamentous and capsular tissues: Ruffini receptors, which are low-threshold and slow-adapting static and dynamic receptors; Pacinian corpuscles, which are low-threshold and fast-adapting dynamic receptors; Golgi tendon organs, which give feedback information about muscle tension to the CNS; and muscle spindles, which convey information about muscle length and rates of changes of length of muscle to the CNS. Riemann & Lephart also found that joint afferents are not as likely to contribute information throughout an entire movement as much as the signals of muscle spindles. These afferent signals for conscious proprioception travel via the dorsal lateral tracts in the spinal cord, but the specific contributions from muscle and joint mechanoreceptors remains largely unknown (Riemann & Lephart, 2002ab).

Previous Research

Suprak et al. (2006) studied the effects of plane and elevation angles on joint position sense accuracy. They found that joint position sense is affected by elevation angle; as elevation angle increased, target error decreased. Suprak et al. attributed this to the simultaneous increase in amount of torque and muscle activation needed to retain the higher target angles. The γ motor neurons that innervate intrafusal muscle fibers are activated at the same time as α motor neurons that innervate extrafusal muscle fibers in the muscle spindle, which are responsible for maintaining sensitivity to changes in muscle length. As muscle tension increases (via contraction or stretching of muscle fibers), there is also an increase in afferent information that is coming from the group Ib golgi tendon organs. With the heightened afferent stimulation coming from the muscle spindle due to the α and γ motor neurons as well as the Ib golgi tendon organs, the decreased target error observed may have been due to this physiological heightening of sensitivity in the muscle due to the increased muscle activation in order to overcome increased gravitational torque (Suprak et al, 2006).

A follow-up study was conducted in order to determine if there were any observable differences between the right and left arms in a similar joint position sense accuracy task. In previous research, there was an asymmetry found when performing this kind of research in a contralateral task. King, Harding, and Karduna did not find any significant differences between target errors of dominant and non-dominant sides. Although there has been prior research that has shown notable differences between the neural control between limbs, regarding factors like coordination of movements and muscle activation patterns, their data suggests that these controls are independent from those of proprioception (King, Harding & Karduna, 2013). Due to a lack of difference between right and left arms caused by shared motor plans, it was deemed only necessary to conduct the study on the dominant limb.

Since proprioception was defined earlier as being comprised of three components, there was a study done by Kim et al. (2014) assessed differences between two of these components; force sense and joint position sense. They utilized two different subject pools: a group with functional ankle instability and a healthy control group. They did this in order to determine if there were any significant deviations between joint position sense and force matching sense in those with damaged receptors in the joint capsule of the ankle, or between the functional ankle instability group and the healthy group. In both healthy and instability groups, no differences were found between force sense and joint position sense when comparing the instability group to the control group and when both measurements within one group were compared (Kim et al, 2014).

Results found in the current literature suggest that the mechanisms from joint position sense and sense of effort are independent entities. This study investigates force matching sense, to see if there will also be a difference in target force accuracy observed than the previous studies that investigated strictly joint position sense of the shoulder. In this study, we hypothesized that there will be an increase in FMS accuracy as elevation angle and torque levels are increased.

Methods

Subjects

Twelve subjects (6 male, 6 female, age 21.3 ± 0.9 years, 75.6 ± 12.3 kg, all right handed) were tested. Subjects self-reported their hand dominance by indicating with which hand they write. Subjects were qualified to participate in the study if they were from the Eugene or university community, and aged 18 to 60 years. Exclusion criteria included: 1) less than 135 degrees of active humeral elevation in the scapular plane; 2) prior shoulder and/or cervical surgery; 3) presence of shoulder pain or pathology; 5) pregnancy. Subjects were briefed on the purpose of the study and the experimental procedure and completed an informed consent form. The Internal Review Board at the University of Oregon approved this study. The experiment required a single session and took approximately one hour.

Experimental Setup

The force acting on a wrist cuff was recorded using a uni-axial load cell (Lebow Products, Troy, MI. Model 3397-50). Force data was sampled at 1000 Hz with custom LabVIEW software (LabVIEW v13.0, National Instruments, Austin, TX). The raw load cell data was converted with a 12-bit A/D converter (NI-USB6221, Netional Instruments, Austin, TX).

Baseline torque was calculated using anthropometric equations for torque due to the arm (1), torque due to the hand (2), and baseline torque (3) (Winter, 2005):

1. $T_{arm} = (BW * 0.05 * 9.81)(sin\theta * l_{arm} * 0.53)$
2. $T_{hand} = (BW * 0.006 * 9.81)(sin\theta * [l_{arm} + \{l_{hand} * 0.506\}])$
3. $Baseline\ Torque = T_{arm} + T_{hand}$

Where T is torque in Newton-meters of the arm or the hand (indicated by subscript), BW is body weight in kilograms, 9.81 is the force due to gravity in meters per second squared, l is the length in centimeters of the arm or the hand (indicated by subscript), θ is the elevation angle of the shoulder, and the percentage of total body mass that is indicated with either 0.53 or 0.506 for the arm and the hand, respectively.

Protocol

Participants were attached to an external load cell by their wrist using non-elastic straps and Velcro to keep their arm secured to the apparatus. Subjects were then instructed about practice trials, in order to accustom them to the shoulder abduction contractions and the visual reality goggles. Once the training portion was completed, official data collection began.

Data was collected at three different angles of shoulder abduction (50, 70, and 90 degrees from vertical), and at three different torque levels (20, 40, and 60% above baseline). A target of two horizontal white lines was displayed on the virtual reality goggles. The subjects then applied an upward force until their cursor was in between the target lines; they maintained this force level for three seconds for memorization before being given a cue to relax. Participants were then asked to replicate the previous force/effort without any visual feedback from the monitor, and then notified the researcher when they felt they matched the previous force/effort level. Once notified, the experimenter recorded the force exerted. One memorization and reproduction of a torque level at a given angle was considered one trial.

Torque levels were recorded four times, which were randomized and collected continuously at a given angle. Angle levels were also randomized, to prevent participant training and the effect of angle or load order.

Figure 1: The experimental setup

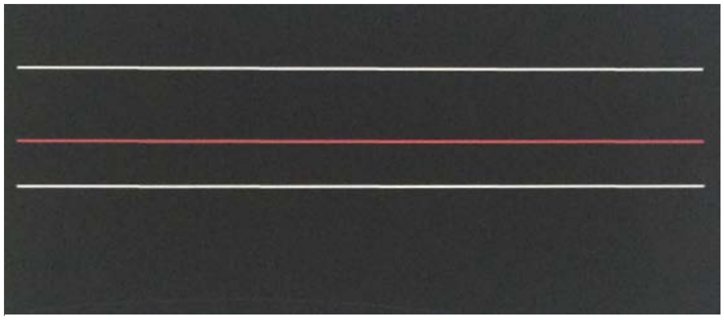

Figure 2: Subject's view of virtual reality goggle display

Statistical Analysis

Statistics were run with SPSS version 22.0 (SPSS Inc.). To detect differences between torque and shoulder angle, as well as differences within each group, a 3 x 3 repeated measures ANOVA was conducted. Independent variables were angle with three levels (50, 70, 90 degrees) and torque with three levels (20, 40, 60 percent above baseline). Follow-up comparisons were performed when appropriate using a Bonferroni and Greenhouse-Geisser adjustments for multiple comparisons and violations of sphericity, respectively. The dependent variable in this study was defined as error from the target in Newton-meters, and was broken up into four groups for analysis: absolute and normalized data, evaluated for constant error (CE) and root-mean-square (RMS) error, all which are explained further in this section. Absolute data was defined as the raw error in Newton-meters that was collected during the experiment. In order to see error as a percentage of baseline torque regardless of the size of the force target, the data needed to be normalized. The data for the normalized data group was calculated using Equation 4:

4. $$(b-a) \Big/ (Baseline + a) = \%\ baseline\ error$$

Where *a* is the percentage of baseline target, *b* is the target produced, and *Baseline* is from Equation 3. This normalized data yields results that are relative to the amount of baseline torque

Statistical analysis for the group data was run on both absolute and normalized data, and for both CE (5) and RMS error (6). Absolute error was considered error in N•m that was not adjusted before analysis. Normalized data was adjusted to represent a percentage of the baseline torque, as seen in Equation 4. CE can be considered as the raw average of the subject's attempt at matching the force target. This computation includes both overshooting (positive) and undershooting (negative) attempts at reproducing the target, which can also be said to show "bias" in the group (Schmidt, 2011). RMS error, also referred to as total variability, can be considered as a measure of "overall error", which is the sum of the squared values of both constant error and variable error (variable error was not considered in the interpretations of the data, but can be thought of as variability of the recorded scores) (Schmidt, 2011).

5. $Constant\ error = \sum(x_i - T)/n$
6. $total\ variability\ (AKA\ RMS\ error) = \sqrt{\Sigma(x_i - T)^2/n}$

Where *x* is the score on trial *I*, *T* is the target force, and *n* is the total number of trials performed by the subject for a given level (Schmidt, 2011).

Results

Absolute data, RMS error

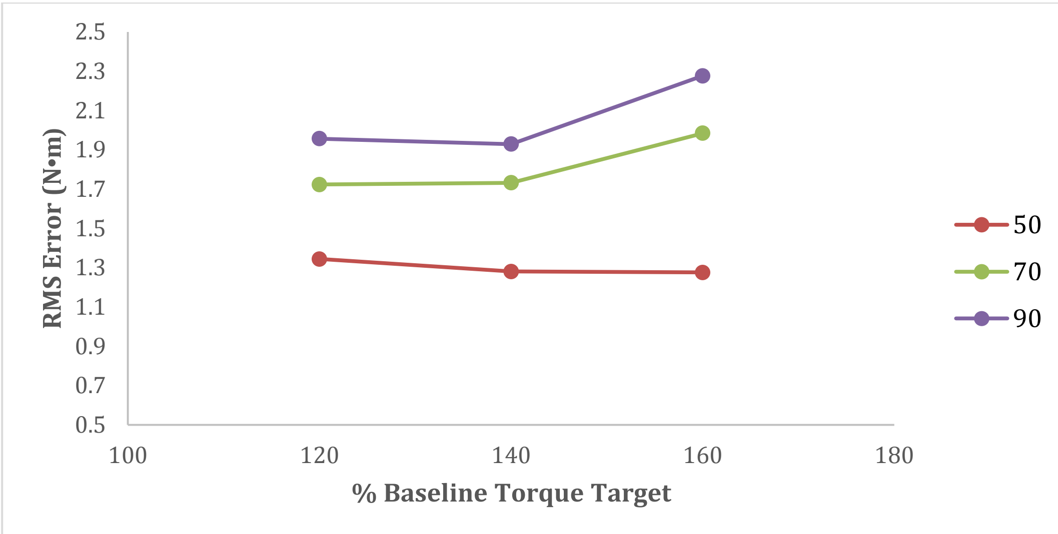

Figure 3: How angle affects target reproducibility for absolute data and RMS error

There was no significant interaction seen between angle and torque level *F* (4, 44) = 0.65, $p > 0.05$. There was also no main effect found for torque level *F* (2, 22) = 0.39, $p = 0.05$. A significant main effect was found for angle *F* (2, 22) = 8.11, $p = 0.002$. Follow-up T-tests were performed with a Bonferroni adjustment for multiple comparisons. A significant difference was found between 50 (*M* = 1.3, *SD* = 0.19) and 90 degrees (*M* = 2.1, *SD* = 0.34).

Absolute data, CE

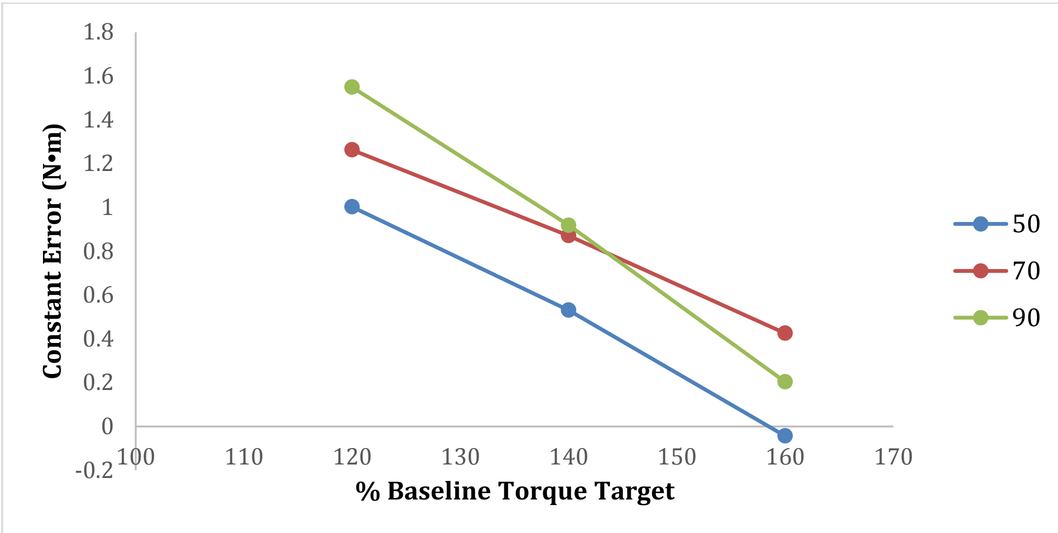

Figure 4: How torque affects target reproducibility for absolute data and CE

The interaction between angle and torque target was found to be insignificant F (4, 44) = 0.72, $p > 0.05$, and no main effect was found for angle F (2, 22) = 1.4, ($p > 0.05$). There was a significant main effect found for torque F (2, 22) = 18.9, $p < 0.01$. A Greenhouse-Geisser adjustment was made for the violation was sphericity, and follow-up T-tests were performed with a Bonferroni adjustment for multiple comparisons. All levels were found to be different from each other ($p < 0.05$), with 20 percent of baseline (*M* = 1.3, *SD* = 0.37), 40 percent of baseline (*M* = 0.77, *SD* = 0.43), 60 percent of baseline (*M* = 0.2, *SD* = 0.5).

Normalized data, RMS error

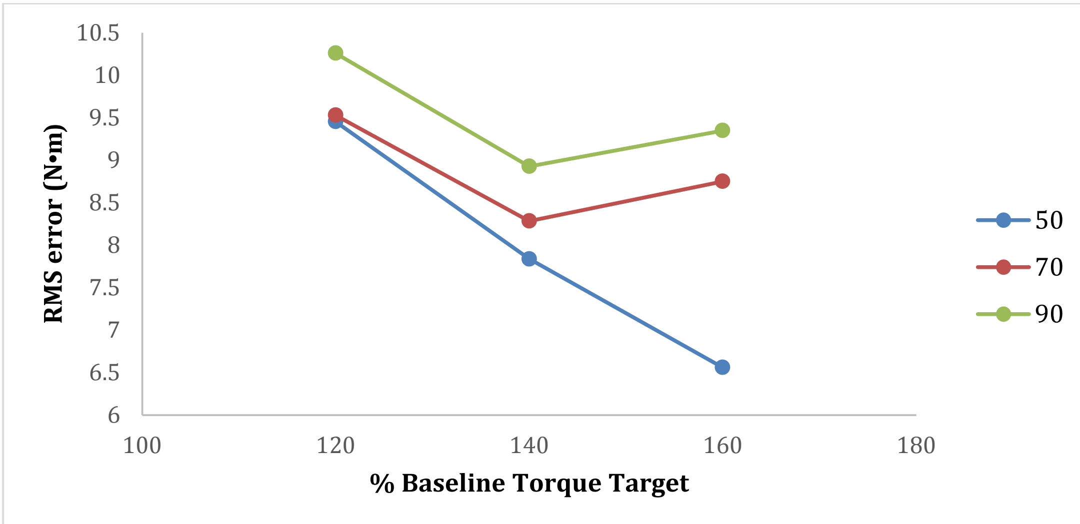

Figure 5: How torque load and angle affect target reproducibility for normalized data and RMS error

Once again, the interaction between angle and torque target was found to be insignificant F (4, 44) = 0.82, ($p > 0.05$). No main effect was found for angle F (2, 22) = 2.2, ($p > 0.05$), as well as torque F (2, 22) = 0.92, ($p > 0.05$).

Normalized data, CE

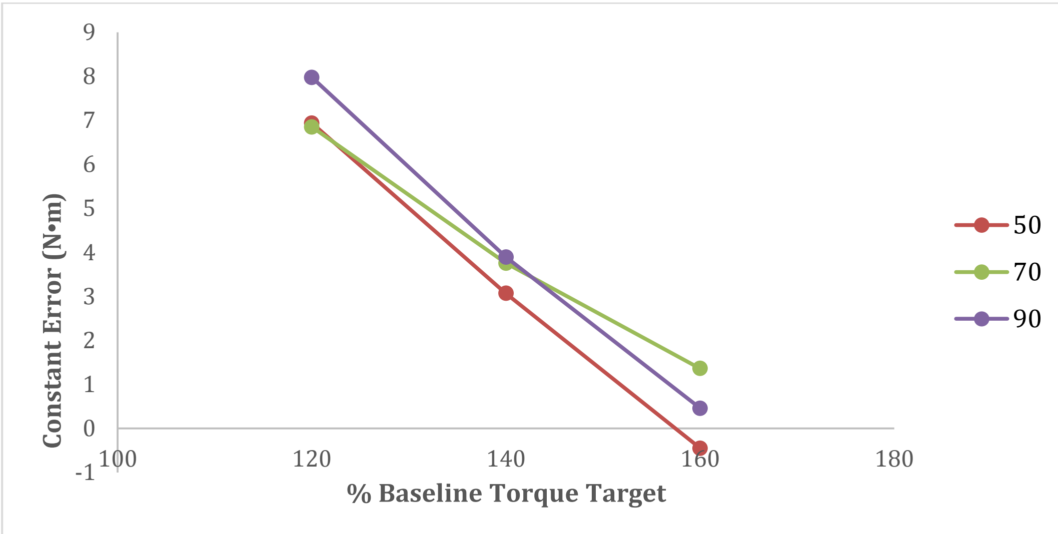

Figure 6: How torque load affects target reproducibility for normalized data and CE

There was no significant interaction between angle and torque target F (4, 44) = 0.6, ($p > 0.05$). There was also no main effect was found for angle F (2, 22) = 0.46, ($p > 0.05$). A significant main effect was found for torque F (2, 22) = 45.2, ($p < 0.01$). A Greenhouse-Geisser adjustment was made for the violation was sphericity. Follow-up T-tests were performed with a Bonferroni adjustment for multiple comparisons. All levels were different from each other with ($p < 0.01$), with 20 percent of baseline (M = 7.3, SD = 2.1), 40 percent of baseline (M = 3.6, SD = 2.3), 60 percent of baseline (M = 0.46, SD = 2.2).

Discussion

The purpose of this study was to investigate the effect of angle and torque load on shoulder FMS. It was hypothesized that due to FMS being one of the key components of proprioception that it would yield similar results to previous JPS studies and increase in accuracy as angle and load were also increased. The relationship with angle and accuracy that holds for JPS of the shoulder was not seen in the present experiment, although there was a similar effect of external load (torque) on FMS accuracy, but possibly for reasons other than an increase in accuracy. Torque and angle did not interact, contrary to the hypothesis.

RMS error had a significant effect for angle when considering absolute torque data, but showed that there was an increase in error as angle decreased, which is opposite of previous JPS research. However, when this data was normalized to a percentage of the baseline torque there was no longer a significant change in error. Even though the error was increasing, it was increasing by a larger amount due to a greater target. RMS shows total variability or “overall error,” which is important to note due to the fact that the amount of overall error of each trial was dependent upon the baseline torque target. These results are indicative of a proportional increase in error that corresponds to the increase in torque experienced by the upper extremity at each target level.

CE was shown to be significant in both absolute and normalized data groups for changes in torque level, showing a decrease in error as torque was increased. However, when looking at those who undershot the target (negative value) versus overshot the target (positive value), there was an observable increase in the number of participants who were falling short of the target level (Table 1). As CE shows bias (or directionality either positively or negatively), it can be susceptible to buffering of the average that was seen among the group. If negative and positive (biased) values are averaged against each other, they could result with a number closer to the target than their absolute scores actually were. Therefore, an increase in undershooters could result in a false representation of target matching accuracy.

Although the present study yielded results that were not consistent with JPS patterns (Suprak & Karduna, 2006), they do suggest that the systems may be separately controlled. Other findings that investigated the relationship between JPS and FMS of the ankle (Kim et al. 2014). Although this study did not directly compare JPS with FMS, the suggestion that they follow independent trends is further supported. It is also suggested that research findings of proprioceptive senses may be systemic, and not dependent on location i.e. the proprioception of the leg may be similar to that of the arm.

A follow-up study, currently underway, is investigating the correlation, if any, between FMS and JPS while controlling for load and joint angle of the shoulder.

Investigating and understanding the systems that contribute to proprioception is significant in many contexts. As proprioception allows us to orient our bodies in space, maintain postural control, and stabilize our joints, understanding how these sensations integrate can have implications for injury and stroke rehabilitation, athletic performance, as well as prevention for proprioceptive loss as we age.

Table 1: The effect of increased torque on the amount of undershooting participants

Torque load	**50**	**70**	**90**	**Total trials undershot/Total**

				trials collected
120%	2	3	1	6/36
140%	3	6	4	13/36
160%	5	6	6	17/36

Limitations

The participants in this study were recruited from the university campus community, and were all under the age of 25. Having such a young population group may mean that the findings in this study are not applicable to the older population, as proprioception accuracy has been shown to decrease with age (Adamo et al. 2009). Another possible limitation to this study was that all the participants were healthy and non-pathological, so these results regarding FMS accuracy may differ among those with a history of shoulder pain and pathology. The contractions that were tested were also isometric, meaning that they did not result in changing the length of the muscle, which could have other effects on FMS that were not investigated in this study.

Conclusions

From these findings, it appears that FMS does not follow the same patterns at JPS when reproducing a force target at different angles. As angle increases, FMS error seems to increase in proportion to the amount of torque experienced, which could explain why the effect is no longer significant when the data is normalized. FMS error decreases with increased torque, but is likely to be a false representation of accuracy due to the concurrent increase in participants who undershot rather than overshot the target.

Appendix

IRB Approval

UNIVERSITY OF OREGON

DATE: January 11, 2016 IRB Protocol Number: 11122015.025

TO: Andrew Karduna, Principal Investigator
Department of Human Physiology

RE: Protocol entitled, "The Effect of Shoulder Angle and External Load on Sense of Effort Proprioception"

Notice of IRB Review and Approval
Expedited Review as per Title 45 CFR Part 46 # 4

The project identified above has been reviewed by the University of Oregon Institutional Review Board (IRB) and Research Compliance Services using an expedited review procedure. This is a minimal risk study. This approval is based on the assumption that the materials, including changes/clarifications that you submitted to the IRB contain a complete and accurate description of all the ways in which human subjects are involved in your research.

This approval is given with the following standard conditions:

1. You are approved to conduct this research only during the period of approval cited below;
2. You will conduct the research according to the plans and protocol submitted (approved copy enclosed);
3. You will immediately inform Research Compliance Services of any injuries or adverse research events involving subjects;
4. You will immediately request approval from the IRB of any proposed changes in your research, and you will not initiate any changes until they have been reviewed and approved by the IRB;
5. You will only use the approved informed consent document(s) (enclosed);
6. You will give each research subject a copy of the informed consent document;
7. If your research is anticipated to continue beyond the IRB approval dates, you must submit a Continuing Review Request to the IRB approximately 60 days prior to the IRB approval expiration date. Without continuing approval the Protocol will automatically expire on January 10, 2017.

Additional Conditions: *Any research personnel that have not completed CITI certificates should be removed from the project until they have completed the training. When they have completed the training, you must submit a Protocol Amendment Application Form to add their names to the protocol, along with a copy of their CITI certificates.*

COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS • RESEARCH COMPLIANCE SERVICES
677 E. 12th Ave., Suite 500, 5237 University of Oregon, Eugene OR 97401-5237
T 541-346-2510 F 541-346-5138 **http://rcs.uoregon.edu**

Research Plan

1. Memo

To:	Committee for the Protection of Human Subjects
From:	David Phillips, MS, CSCS, Katya Trousset, Andrew Karduna, PhD
Date:	30 October 2015
Subject:	New Protocol

Please consider the attaching application for a new protocol entitled: "The Effect of Shoulder Angle and External Load on Sense of Effort Proprioception." In addition to this memo, the application contains the following:

1) Initial IRB Application
2) Research Plan
3) Consent Form
4) Subject intake form
5) Flyer
6) Online Flyer
7) Karduna CV

2. RESEARCH PLAN

A. Introduction and Background

Proprioception is the interpretation of incoming sensory information from skin, joints and muscles to determine a limb's orientation in space and current postural status. Proprioception can be divided into the submodalities of kiesnthesia, which is the detection of joint movement, joint position sense (JPS) and sense of effort (Riemann & Lephart, 2002a). Proprioception is needed for the body to detect its interactions within the environment that cannot be visually determined. This allows adjustment of a limb's position without needing to see the limb (Sarlegna & Sainburg, 2009). The high mobility and low stability trade off at the shoulder means proprioception is particularly important at this joint (Janwantanakul, Magarey, Jones, & Dansie, 2001).

In activities of daily living proprioception is required to continually update and correct movements. Joint position sense ensures that a limb is placed in the correct position to perform the task while force sense ensures that correct amount of strength is used to maintain control of objects and movements (Riemann & Lephart, 2002b). Both JPS and force sense are required to successfully perform activities of daily living.

While JPS at the shoulder improves with shoulder elevation and external load (D. N. Suprak, Osternig, van Donkelaar, & Karduna, 2007; D. Suprak, Osternig, & Karduna, 2005) and is similar between left and right arms (King, Harding, & Karduna, 2013), to our knowledge no study has investigated sense of effort at the shoulder joint. It is hypothesized that proprioception errors will be less at higher abduction angles and at higher external loads.

B. Specific Aims/Study Objectives

The purpose of this study is to investigate external load and shoulder abduction angle effects on sense of effort proprioception. The parameters are muscle strength and error in the sense of effort proprioception task. (A secondary aim would be to observe if there is any difference in ipsilateral dominance (handedness) associated with force matching sense.)

C. Material, Methods and Analysis

<u>Procedure</u>

Potential participants will be pre-screened only by the phone. During this screening, participants will be informed of the procedures, time requirement and potential discomfort related to the study. Screening is to ensure that participants are healthy and do not have any shoulder pathology. Participants will stand while their dominant arm is tested. Maximum shoulder strength through a maximal voluntary contraction at each angle will be recorded first. Participants are attached to an external load cell at the wrist using non elastic lifting straps and Velcro. Participants are instructed to abduct their arm against the straps as hard as possible for five (5) seconds while the reading is recorded.

Data is collected at different angles of shoulder abduction. The subjects will apply a force onto the load cell until it matches the guide on the monitor. The subjects will be instructed to memorize that sense of effort/force perception and then relax. The subject will briefly relax and then be instructed to reapply the memorized force/effort without the monitor for feedback and indicate to the researcher when they believe they are at the memorized force level. This level will be recorded. The process of memorizing and reproducing a force is considered a trial. This will be repeated at varying force levels, up 20 trials for each shoulder angle. The number of trials collected for each subject may vary depending on the individual subject's performance in the task and variability of the data but will not exceed 20 trails for each angle. The protocol is then repeated on the opposite arm.

All procedures will be completed in a single session and will be finished in approximately two (2) hours. The informed consent form may take 5 to 15 minutes to complete depending on the number of questions the participants asks.

Methods

A Lebow load cell (Lebow Products Inc, Toronto, Canada) will measure the external force application at a frequency of 1000 Hz by a custom Labview program and recorded to a hard drive for later analysis.

Analysis

The difference between the memorized force/effort and reproduced force/effort will be calculated from the stored data.

D. Participant Population & Recruitment Methods

Participant Population & Research Setting

The subjects will be recruited from the university community, thus we expect there to be a mix of men and women from a variety of ethnic backgrounds. The age range of the subjects will be 18 to 60 years. The study will be conducted in the laboratory setting with the use of an external load cell.

Participant Recruitment

Subjects will be recruited through word of mouth, flyers posted around the UO campus and online advertisement. Only healthy individuals will be recruited for this project. Subject exclusion criteria for the study is as follows: 1) less than 135 degrees of active humeral elevation in the scapular plane; 2) prior shoulder and cervical surgery; 3) presence of shoulder and neck pain preventing the correct execution of tests; 4) had history of cervical or shoulder pain or pathology; 5) pregnancy. Subjects will be asked to lift their arm to their ear to ensure a greater than 135 degrees range of motion. Pregnancy will be assessed verbally prior to beginning the study. No pregnancy testing is performed due to the non-invasiveness and low risk of the experiment. The potential subjects may be screened by phone or face to face depending on the method of recruitment. The subjects who qualify for the study will then be invited to go to the lab to participate in the study.

Recruiting Aids

There is no compensation or recruiting aids for this study.

Recruiters

Katya Trousset will be responsible for recruiting participants.

E. Informed Consent Procedure

When the subjects arrive at the laboratory, an orientation period will allow for any clarification of points in the consent form. The experimental protocol will be explained in detail to the subject and they will have the opportunity to ask questions. Subjects will be reminded that they may withdraw from the study at any time. One of the personnel listed as research staff will perform the informed consent procedure. All of them have completed the CITI human subjects training.

F. Provisions for Participant and Data Confidentiality:

Each subject will be given a subject ID that will identify the study and subject number. For example, the code "SoE12" indicates the subject was involved in the sense of effort study, and that he/she was the 12th subject. After the data are copied into an Excel file without identifiers, the files will be kept locked in a filing cabinet, which is in a locked office. Computer data files will be stored in the password protected computers in the Orthopaedic Biomechanics Laboratory and backed up on appropriate media. Only the investigators and faculty advisor will have access to the data. Subjects could be identified by name and demographics. However, all information regarding subject name, gender, phone number, address, etc. will be kept locked in a file cabinet. The archived raw data will not be destroyed because it is the intent of the PI to utilize these data in future research projects.

G. Potential research risks or discomforts to participants

No psychological, emotional, social, or legal risks related to the project have been reported, but there may be some physical risks involved with the strength measures. During maximum voluntary contraction or increasing muscle contraction at up to MVC, the subjects may feel muscle soreness or muscle fatigue. However, because the subjects are healthy and the duration of the contraction is short, the risk would be very low. The investigator will monitor the condition of the subjects and stop the test if needed.

H. Potential research benefits to participants

The individual subjects in this study will gain no direct benefits. The results of this study may provide more information to researchers looking muscle pathologies at the shoulder. This information will help to develop new shoulder evaluation techniques.

I. Investigator experience

The PI, Andrew Karduna, PhD, is an Associate Professor in the Department of Human Physiology at the University of Oregon. Before coming to Eugene, Dr. Karduna spent 6 years as a faculty member in the department of Rehabilitation Sciences MCP Hahnemann University in Philadelphia. For the past 16 years, Dr. Karduna has been conducting research in the area of shoulder biomechanics. He has published numerous peer-review journal articles in this field. David Phillips, who is the main student working on this project, has received one-on-one training with Drs. Karduna. He has also conducted previous biomechanical research at Barry University and physiological research at the University of Pretoria with the approval of the appropriate IRB and Ethical Committees.

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University of Oregon Department of Human Physiology
Informed Consent for Participation as a Subject in
"The Effect of Shoulder Angle and External Load on Sense of Effort Proprioception"
Investigator: Katya Trousset, David Phillips, MS, CSCS

Introduction

You are being asked to take part in a research study of sense of effort, a component of proprioception. You were selected as a possible participant because you are generally in good health and have no shoulder problems. We ask that you read this form and ask any questions that you may have before agreeing to be in the study.

Purpose of Study:

The purpose of this study is to investigate external load and shoulder abduction angle effects on sense of effort proprioception.
Participants in this study are from the University of Oregon and Eugene communities.

Description of the Study Procedures:

If you agree to be in this study, we would ask you to participate in one session of testing. The session will last approximately one and a half hours. We will ask you to do the following things, during the session:

First of all, you will be asked to elevate your arm as hard as you can against manual resistance, to measure the maximal force you can apply against a load cell. After that, the sense of effort of your shoulder will be tested. Your wrist will be strapped to a load cell. After that you will apply different levels of submaximal force (≤50% of maximum) up 20 times to the load cell for each shoulder angle. You will be given visual feedback of the force level. You will memorize the amount of effort on each occasion and then reproduce that effort without visual feedback.

The informed consent procedure and the completion of a subject intake form may take from 5 to 15 minutes. The measurement of maximum strength will take 5 minutes. The total testing time will not exceed 2 hours.

Risks/Discomforts of Being in the Study:

The study has the following risks. You may also feel light muscle soreness after the test (up to two days). However, because you are healthy and have no shoulder problems, the risk will be very low, equivalent to the sensation following physical exercise.

Benefits of Being in the Study:

The purpose of the study is to investigate the sense of effort, a component of proprioception a different levels of force and shoulder abduction angles. There is no direct benefit to you by participating in this study. However, you understand that information gained in this study may help health care professionals develop better protocols to evaluate shoulder pathologies.

Payments:

There is no compensation for your participation in this study.

Costs:

There is no cost to you to participate in this research study.

Confidentiality:

The records of this study will be kept private. In any sort of report we may publish, we will not include any information that will make it possible to identify you as a participant. Research records will be kept in a locked file. All electronic information will be coded and secured using a password protected file.

Access to the records will be limited to the researchers; however, please note that regulatory agencies, and the Institutional Review Board and internal University of Oregon auditors may review the research records.

Voluntary Participation/Withdrawal:

Your participation is voluntary. If you choose not to participate, it will not affect your current or future relations with the University of Oregon. You are free to withdraw at any time, for whatever reason. There is no penalty or loss of benefits for not taking part or for stopping your participation.

Dismissal From the Study:

The investigator may withdraw you from the study at any time for the following reasons: (1) withdrawal is in your best interests (e.g. side effects or distress have resulted), or (2) you have failed to comply with the study requirements.

Disclaimer Statement and Compensation for Injury:

If you experience an emergency medical problem or injury as a direct result of your participation in this research, the investigators of the study will do everything they can to assist you. However, cost of care due to any injury will be covered by the participant and/or his/her insurance company.

Contacts and Questions:

The researcher conducting this study is David Phillips. For questions or more information concerning this research you may contact him at (541) 346-

0438, Department of Human Physiology, University of Oregon, Eugene OR, 97403. If you believe you may have suffered a research related injury, contact David Phillips and he will provide you with further instructions.

If you have any questions about your rights as a research subject, you may contact: Research Compliance Services, University of Oregon at (541) 346-2510 or ResearchCompliance@uoregon.edu

Copy of Consent Form:

You will be given a copy of this form to keep for your records and future reference.

Statement of Consent:

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Signatures/Dates

____

Study Participant (Print Name)

____

Participant Signature **Date**

Subject Intake Form

Project: "The Relationship between deltoid EMG and Shoulder Abduction Force and the Effect of Fatigue"

Name ______________________ Subject Code ___________________

Date ______________________ Dominant Side __________________

Right Arm Length________________ Left Arm Length________________

Age ___________________________ Gender ____________________________

Healthy Volunteers Needed for a Study of Shoulder Proprioception

- **If you are healthy and never had a problem with your neck or shoulder, you may be eligible to participate.**

- **The testing requires approximately 2 hours**

- **Testing is non-invasive requires lifting the arm as hard as possible and at low contraction levels**

For more information contact the Orthopaedic Biomechanics
Laboratory (mention the shoulder sense of effort study).
Phone: 346-0441; Email: katyatrousset@gmail.com

Online Recruitment Flier

Title: Healthy participants needed for a study of shoulder proprioception

We are conducting research related to proprioception at shoulder control. Proprioception is the awareness of where a limb is in space without vision. If you are healthy and have never had any problems with your shoulder and neck, you may be eligible to participate.

Testing is non-invasive. You will perform several muscle contractions to test your Strength follow by low level contractions. It is estimated that the entire testing process will take approximately 2 hours.

Please call the Orthopaedic Research Lab at University of Oregon to find out more about the Sense of Effort study (541) 346 0441, or email Katya Trousset katyatrousset@gmail.com

Consent Form

University of Oregon Department of Human Physiology
Informed Consent for Participation as a Subject in
"The Effect of Shoulder Angle and External Load on Sense of Effort Proprioception"
Investigator: David Phillips, Katya Trousset

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Signatures/Dates

____

Study Participant (Print Name)

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Participant Signature **Date**

CITI Certificate

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI)

HUMAN RESEARCH CURRICULUM COMPLETION REPORT

Printed on 06/09/2014

LEARNER	Katya Trousset (ID: 4183842)
DEPARTMENT	Human Physiology
EMAIL	trousset@uoregon.edu
INSTITUTION	University of Oregon
EXPIRATION DATE	06/08/2016

STUDENT RESEARCHERS

COURSE/STAGE:	Basic Course/1
PASSED ON:	06/09/2014
REFERENCE ID:	13100397

REQUIRED MODULES	DATE COMPLETED	SCORE
Students in Research	05/29/14	10/10 (100%)
Unanticipated Problems and Reporting Requirements in Social and Behavioral Research	05/29/14	3/3 (100%)
University of Oregon	05/29/14	No Quiz
ELECTIVE MODULES	**DATE COMPLETED**	**SCORE**
The Regulations - SBE	06/09/14	5/5 (100%)
Assessing Risk - SBE	06/09/14	5/5 (100%)

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI Program participating institution or be a paid Independent Learner. Falsified information and unauthorized use of the CITI Progam course site is unethical, and may be considered research misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Program Course Coordinator

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