THE EFFECT OF AGE ON SHOULDER JOINT PROPRIOCEPTION

by

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A THESIS

Presented to the Department of Human Physiology
and the Robert D. Clark Honors College
in partial fulfillment of the requirements for the degree of
Bachelor of Science

June 2018

An Abstract of the Thesis of

Amanda Davenport for the degree of Bachelor of Science
in the Department of Human Physiology to be taken June 2018

Title: The Effect of Age on Shoulder Joint Proprioception

Approved: ____

Andrew Karduna, PhD

Despite the increased prevalence of shoulder abnormalities with age, no identified study had analyzed the effect of age on shoulder joint proprioception. Based on previous research of proprioceptive changes at other upper extremity joints, our primary hypothesis was that older individuals would experience decreased shoulder joint proprioception when compared to younger individuals. We tested joint reposition accuracy in subjects aged 18-25 with an iPhone application designed to measure joint position sense. We obtained data regarding joint reposition accuracy in individuals aged 48- 55 from the 2012 American Society of Biomechanics Annual meeting. We detected no significant influence of age on constant error (p=0.456) or variable error (p=0.106). We secondarily worked to affirm previous claims that shoulder flexion angle affects repositioning accuracy. Our secondary hypothesis was that individuals would demonstrate greater repositioning accuracy as the target flexion angle increased from 0° to 90°. We detected significant influence of target angle on constant error (p=0.001). We detected no significant influence of target angle on variable error (p=0.106).

Acknowledgements

I would like to thank Professor Andrew Karduna, Professor Samantha Hopkins, and Graduate Teaching Fellow Kate Spitzley for volunteering their time and effort to be members of my thesis committee.

Thank you, Andrew Karduna, for the opportunity to conduct research in the Orthopaedic Biomechanics Lab and for taking on the role as my primary advisor in my first thesis project. I appreciate the autonomy granted to me throughout the process. You provided a situation in which I simultaneously felt responsible and accountable for progress and supported enough so as to not experience unnecessary stress.

Thank you, Kate Spitzley, for helping me compose this project. You have guided me on how to effectively and comprehensively articulate my collected information. I so appreciate your willingness to edit multiple drafts throughout the process, your positive acknowledgments of improvement, and your encouragement for further development.

Thank you, Sam, for providing me feedback regarding the fine-tune details of my project. You have supplied guidance regarding the parameters of the project – and have kept me from having to search through multiple documents for formatting answers.

I would also like to thank the subjects who volunteered their time and allowed me to explore my questions of interest. And to my friends and family for constant words of encouragement, I am so thankful.

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Background

The interactions between bones and muscles provide the rudimentary mechanism for human movement. As muscle fibers contract, force is transmitted through an attachment site to the bone, producing skeletal movement. At a joint, this mechanism alters bone positions relative to one another and creates angular limb changes. Joints have inversely related degrees of mobility and stability so that a joint with greater mobility has less stability and vice-versa.

The shoulder joint is extremely mobile as a result of its abundant loose tissue, lax shoulder capsule, and similarly lax capsulolabral ligaments (Warner et al., 1996). Additionally, the two largest bones of the shoulder joint, the humerus and the scapula, have low boney congruency. The humeral head is large and round while the glenoid fossa of the scapula is shallow. The amount of boney interaction at this articulation site is resultantly small (Davies & Dickoff-Hoffman, 1993).

Proprioception helps combat the increased risk of shoulder injury due to this mobility (Suprak et al., 2006). Proprioception, commonly referred to as body awareness, is a subcategory of the somatosensory system and is often measured with joint position sense, kinesthesia, and sense of force (Konradsen, 2002; Docherty et al., 2004). Proprioceptors initiate the propagation of somatosensory information from muscles, tendons, and joints to the central nervous system (CNS) via afferent neurons (Taylor, 2009). The brain interprets this information and determines an appropriate motor action, which is propagated via efferent neurons away from the CNS (Hillier et al., 2015).

The proprioceptive system consists of multiple types of sensory organs. Muscle spindle fibers are embedded in muscle bellies and sense changes in muscle length and contraction velocity (Hillier et al., 2015). Spindle fibers initiate afferent signals regarding muscle contraction and elongation (Tresilian, 2012). Golgi tendon organs are activated by, and initiate afferent signals regarding force applied at musculotendonous junctions (Tresilian, 2012). Articular proprioceptors include Pacinian receptors, Ruffini receptors, ligament receptors, free nerve endings, and Golgi endings (Tresilian, 2012). They are situated within the soft tissues and ligaments of joints and detect tension particularly at extreme ranges of motion (Hillier et al., 2015).

Cutaneous proprioceptors located in the skin and underlying tissues assist musculoskeletal proprioceptors in position sense. Merkel disk receptors, Meissner corpuscles, and Pacinian corpuscles are sensitive to skin compression (Tresilian, 2012). These proprioceptors initiate afferent signals when pressure is applied to or removed from the skin but not during sustained compression. This is exemplified in a watch being noticeable when put on a wrist but relatively undetectable throughout the day if it stays put. Hair follicle receptors are activated by hair deflection and, similarly, do not initiate proprioceptive signals with sustained deflection (Tresilian, 2012). Ruffini end organs are activated by the cutaneous stretch associated with musculoskeletal movement (Hillier et al., 2015).

Proprioceptors are subject to morphological degeneration over time, both naturally and as a result of physical injury (Lephart et al., 1997). Muscle spindle fiber capsules thicken and contribute to muscle denervation (Shaffer & Harrison, 2007). Additionally, the total number of fibers in each spindle diminishes with time and the remaining fibers demonstrate reduced diameters (Shaffer & Harrison, 2007). The number of articular and cutaneous proprioceptors in the shoulder joint and fingers, respectively, also decreases with age and the remaining proprioceptors exhibit reduced sizes (Shaffer & Harrison, 2007). The degeneration of proprioceptors reduces their physiological sensitivity with increased age.

The morphological degeneration of proprioceptors over time, however, does not necessarily reflect the change in proprioception as a whole. Proprioception is multifaceted as it consists of both physiological and cognitive components. The propagation of somatosensory information to the brain is a physiological response to proprioceptor activation. The perception of this information and creation of a motor response requires cognitive interpretation. Thus, proprioception is optimized when the propagation and interpretation of information each function optimally (Han et al., 2016).

Through repetition, the brain becomes more adept to interpreting incoming information and planning appropriate motor responses. The planning cortices of the brain formulate a command that results in physical movement and interaction with the environment. An internal efference copy of the command is sent to the cerebellum for a prediction to be made regarding the sensory feedback associated with the command. The cerebellum compares the predicted and actual sensory feedback, determines discrepancies between the two, and makes necessary adjustments (Blakemore, Frith, & Wolpert, 2001).

The efference copy associated with a movement is stored in the brain so that future execution of the same movement is improved (Blakemore, Frith, & Wolpert, 2001). Likewise, repetitive proprioceptive stimulation increases the proprioceptive information associated with a stored efference copy. This suggests that the stimulation of the same proprioceptors during a repeated movement increases an individual's ability to interpret the proprioceptive information associated with the movement (Willingham, 1998). Increased interpretation of proprioceptive information is also a result of biochemical changes in the brain. Continued stimulation of a proprioceptor causes long-term potentiation that alters the function of its associated synapses and indicates learning within the brain (Berke & Hyman, 2000). A repeated movement stimulates the same proprioceptors and enhances interpretation within the neuronal synapses.

Proprioceptive differences have been noted across different ages in certain joints. Research of upper extremity proprioception has focused on the elbow, metacarpophalangeal, and radiocarpal joints (Kalisch et al., 2012). Researchers have concluded that older subjects produce greater error during wrist position-matching tasks and elbow position-matching tasks than their younger counterparts (Adamo, Martin, & Brown, 2007; Adamo, Alexander, & Brown, 2009). Additional researchers noted a significant decrease in finger joint position sense with increased age (Kalisch et al., 2012). However, Kalisch et al. analyzed individuals in their upper seventies without initially assessing memory function. As a result, it is nearly impossible to determine if his observations were due to proprioceptive changes or age associated memory changes.

More frequently in proprioceptive research, the effect of age on proprioception is noted as a secondary observation and not controlled for. Therefore, the primary purpose of this study is to analyze the effect of age on shoulder joint proprioception. We hypothesize that individuals aged 18-25 will display greater proprioceptive abilities than individuals aged 48-55. Greater proprioceptive ability refers to increased accuracy in recreating a previously experienced body position. The secondary purpose of this study is to analyze whether or not shoulder flexion angle affects repositioning accuracy. We hypothesize that repositioning accuracy will increase as flexion angle increases from 0° to 90°.

Introduction

Anatomical structures, physiological functions, and neural circuitry are susceptible to transformation over time. Previous researchers have more specifically noted impaired muscle composition, reflexivity, and nervous system activity in older individuals. Numerous syndromes and injuries simultaneously become more prevalent with age. The relationship between these changes and the increased prevalence of such conditions require independent analysis of each.

Muscle mass is significantly compromised in 8.8% of younger individuals compared to 17.5% of older individuals (Malafarina et al., 2011). This may result from atrophy of fast-twitch muscle fibers, altered tropic hormone secretion, or slowed actin and myosin synthesis (Morley et al., 2000). Laryngeal, vestibulocollic, vestibular, and occulomotor reflexivity is similarly compromised with increased age (Erskine et al., 1993; Welgampola & Colebatch, 2001; Peterka, Black, & Schoenhoff, 1989). The greater prevalence of neuropathy in individuals over the age of 65 also demonstrates neural plasticity (Verdú et al., 2000; Martyn & Hughes, 1997). These changes highlight the fact that sensorimotor systems are not static.

These changes call into question additional sensorimotor systems such as proprioception, suggesting that they may likewise be affected by age. As previously mentioned, certain joints demonstrate declined proprioception with increased age. However, the effect of age on proprioception has been of focus primarily in lower extremity joints (Kalisch et al., 2012). This emphasis may most likely be attributed to the relationship between lower extremity proprioception and balance (Han et al., 2015). Due to the substantial fall risk in older populations, researchers have prioritized studying proprioception in the lower extremity to reduce this issue**.**

The relatively few experiments that have analyzed the effect of age on proprioception in the upper extremity have excluded the shoulder joint (Kalisch et al., 2012). Proprioceptive researchers that have focused on other upper extremity joints have found a common decrease in proprioception with increased age (Adamo, Martin, & Brown, 2007; Adamo, Alexander, & Brown, 2009; Kalisch et al., 2012). This suggests that shoulder proprioception will similarly become compromised with age. However, to my knowledge, controlled analysis of the effect of age on shoulder joint proprioception does not exist.

Analysis of shoulder proprioception is necessary due to the heightened prevalence of shoulder pain, syndromes, and injuries in older individuals. These conditions include instability, rotator cuff damage, and impingement. Reported shoulder pain increases from 2.3% in individuals 25-34 years of age to 8.2% in individuals 45-54 years of age and even further to 13.2% in individuals aged 74-85 years of age (Luime et al., 2004). The increased shoulder pain associated with aging provides a rationale for studying these conditions in light of all potential anatomical, physiological, and neurological changes, including proprioception.

As the deltoid muscle, rotator cuff tendons, and glenohumeral ligaments deteriorate with age, shoulder joint instability increases and dislocation becomes more prevalent (Porcellini et al., 2006). Also associated with this deterioration is an increased rate of rotator cuff injury in asymptomatic shoulders (Tempelhof, Rupp, & Seil, 1999). Shoulder impingement refers to a reduction of space within the glenohumeral and subacromial joints. Like instability and rotator cuff damage, shoulder impingement significantly increases with age (Kircher et al., 2014).

Proprioceptive changes are rarely considered in regards to these conditions. Though alternative mechanisms have been proposed for these conditions, a potential change in proprioception due to physiological deterioration of proprioceptors may also contribute. Therefore, it is necessary to determine the effect of age on shoulder joint proprioception so as to determine if a correlation exists between proprioceptive change and the prevalence of shoulder abnormality. This determination may enhance health care providers in patient treatment.

Proprioception is most commonly analyzed through three testing methods. These methods include threshold to detection of passive motion, active movement extent discrimination, and joint position reproduction. Each assessment technique has unique benefits and drawbacks, provided the analytical intention (Han et al., 2016). Joint position reproduction, however, is relatively efficient and intuitive as it capitalizes on an individual's self- awareness of joint placement and positioning. During a joint position reproduction test, the subject achieves a joint angle for some time and later attempts to recreate the angle (Han et al., 2016).

A significant consideration regarding joint position reproduction is that it depends on sufficient memory. The technique utilizes a method common to psychophysical experimentation known as the method of adjustment. This method requires the subject to adjust the magnitude of a stimulus in an anatomical location until they achieve a magnitude equal to that of a previously achieved reference stimulus (Han et al., 2016). The subject must draw on their memory of the reference stimulus to do so. Therefore, this type of proprioceptive testing is less effective on subjects with cognitive and memory deficits (Han et al., 2016). The prevalence of cognitive irregularities in older aged individuals contributes to the difficulty of assessing the dynamic between proprioception and age.

By the age of 65, 40% of individuals experience age associated memory impairment (Small, 2002). Researchers utilizing age as an independent variable must consider the potential impact of cognitive impairment on their findings. Two main considerations should be made when determining appropriate age ranges for an age comparison study. The first consideration should be that the two cohorts be separated enough to provide maximal potential for observable, significant differences between them. The second consideration should be that the older cohort be considerably younger than the aforementioned 65 years of age at which age associated memory impairment becomes substantial. If this cohort approaches or exceeds this age, it may be worthwhile to screen subjects for cognitive impairment to best control for proprioceptive changes.

Isolating proprioception for experimental analysis remains difficult, as it is a single component of the entire somatosensory system. Successfully isolating proprioception from vision proves particularly challenging. Individuals coalesce proprioception and vision to interpret limb orientation and spatial positioning. Previous researchers have found that, with simultaneous stimulation, the CNS more heavily relies on vision than proprioception (Van Beers et al., 1999). Consequently, it is imperative to remove vision entirely and isolate proprioceptive feedback when testing proprioception.

Expanding on this concept of proprioceptive isolation, it is also necessary to isolate the proprioceptors of interest from those of disinterest. In the case that shoulder joint proprioception is of interest, input from additional proprioceptors in the hands, legs, feet, and so on should be minimized. Joint position reproduction maximizes the analysis of isolated proprioceptors due to its relatively static environment (Han et al., 2016).

The development of this study was particularly affected by the notable occurrence of age associated memory impairment in individuals 65 years of age and older. This study attempts to explore the physiological and cognitive changes associated with proprioception as opposed to those associated with memory loss. Given the aforementioned percentage of people affected by age associated memory impairment at age 65, this study analyzes subjects aged 18- 25 and 48- 55. This spread optimizes the potential for proprioceptive differences between the two cohorts without encroaching on 65 years of age.

The primary purpose of this study is to analyze the effect of age on shoulder joint proprioception. We hypothesize that the physiological decline of proprioceptors will dominate the cognitive pruning of proprioceptive interpretation and that the younger cohort will more accurately recreate shoulder joint angles than the older cohort. The secondary purpose of this study is to analyze the effect of shoulder flexion angle on reposition accuracy. We hypothesize that individuals will exhibit greater repositioning accuracy as the flexion angle increases from 0° to 90°. The subject's proprioceptive abilities will be measured through joint position reproduction.

Methods

Subjects

Participants were 10 younger individuals (21.9 years +/- 1.45 years) from the University of Oregon and 10 older individuals (50.9 years +/- 2.28 years) selected from data from the 2012 American Society of Biomechanics Annual meeting (Edwards et al., 2016). Exclusion criteria included previous shoulder surgery, shoulder joint macrotrauma, and shoulder joint pathology. The younger cohort participated in a single 30- minute testing session at the Orthopaedic Biomechanics Lab on the University of Oregon campus. The older cohort participated in the same testing protocol in Gainesville, Florida at the conference (Edwards et al., 2016). Twenty students were initially tested and 10 were included in the study to match the sex of the 10 participants included from the conference. The Internal Review Board at the University of Oregon approved each study and participants signed a consent form prior to experimentation (see Appendix).

Instrumentation

The Orthopaedic Biomechanics Lab and InfoGraphics department designed Joint Position Sense (JPS), an application for an Apple iPod Touch. It uses a triaxial accelerometer gyroscope to calculate the device's angle with respect to gravity (Edwards et al., 2016). The use of this triaxial accelerometer to collect data has previously been validated (Amasay et al., 2009).

Protocol

The shoulder joint was the focus of this experiment. Therefore, the iPod was strapped to the lateral side of the subject's dominant humerus. Individuals of the younger cohort answered a series of verbal questions to determine dominance (see Appendix). Individuals of the older cohort self-determined arm dominance.

This protocol measured joint position sense in each subject during shoulder flexion. Subjects completed practice trials prior to data collection. Throughout the experiment, they sat with their eyes closed and back straight. The younger subjects sat in an ergonomic chair with the soles of their feet off the floor. The older subjects sat on a stool with their feet flat on the ground (Edwards et al., 2016). Subjects were instructed to keep their movement in the sagittal plane with their thumb pointed towards the ceiling and elbow joint fully extended.

Figure 1. Subject in Resting Position.

This protocol tested three target angles: 50°, 70°, 90°. Each subject achieved the target angles with auditory instruction from the JPS application. The younger cohort received auditory instruction from a speaker in the iPod. The older cohort received auditory instruction through headphones. The subject started the trial with their dominant arm by their side. The JPS application created a low frequency tone, indicating that the subject's arm was below the target angle. The subject flexed at his or her should joint, increasing the flexion angle until the JPS application silenced. This silence indicated that the subject was within plus or minus 2° of the target range. If the subject overshot, the JPS application created a high frequency tone, indicating that the subject was above the target angle.

Figure 2. Subject in Target Angle Position.

The subject maintained the target flexion angle for two seconds and was instructed to memorize the position of their arm. The subject returned to his or her starting position. After three seconds, the application then instructed the subject to “find target angle” and recreate the memorized angle without auditory instruction. The subject returned to their starting position and the first trial was complete.

Each of the three target angles was presented four separate times in a randomized order. Each subject completed a total of 12 trials. After 12 trials, the JPS application audibly indicated that the experiment was complete and the armband was removed from the humerus.

Data Analysis

The JPS application recorded the angle achieved with auditory instruction and the angle achieved without auditory instruction. This data was stored on the application and downloaded onto a laptop with LabVIEW version 16. LabVIEW produced a waveform for each trial that displayed two shallow spikes. The first spike represents the angle achieved with auditory instruction. The second spike represents the angle achieved without auditory instruction. LabVIEW calculated the reposition angle error for each trial by subtracting the presented angle from the repositioned angle. Positive reposition angles demonstrated overshoot and negative reposition angles demonstrated undershoot.

The presented angle, repositioned angle, and reposition angle error for each trial were copied into Excel and were used to generate the constant error and variable error. The constant error of each flexion angle was calculated using the following equation:

$$M_E=\Sigma(A_R)/n \qquad (1),$$

where M_E represents constant error, A_R represents the repositioned angle, and n represents the number of trials. The variable error of each flexion angle for each subject was calculated using the following equation:

$$V_E=\sqrt{[\Sigma(A_R-M_E)^2)/n]} \qquad (2),$$

where V_E represents variable error, A_R represents repositioned angle, M_E represents constant error, and n represents the number of trials. In all calculations, n=4 because each subject completed 4 trials of a single joint flexion angle.

Statistical Analysis

The constant error values and variable error values of each angle were compiled in SPSS version 25.0. This software was used to perform two, two-way repeated measures analysis of variance (ANOVA). The first ANOVA was performed with the independent variables defined as angle (50°, 70°, and 90°) and age (younger, older) and the dependent variable defined as constant error. The second ANOVA was performed with the same independent variables and the dependent variable defined as variable error. The designated alpha level of the statistical analysis was 0.05.

Results

Constant Error

The ANOVA performed yielded no significant interaction between angle and age (p=0.242). There was also no significant influence of age on accuracy (p=0.456). There was significant influence of target angle on accuracy (p=0.001). Average constant error at each target angle and standard error of the mean is graphed for each age cohort (Figure 3).

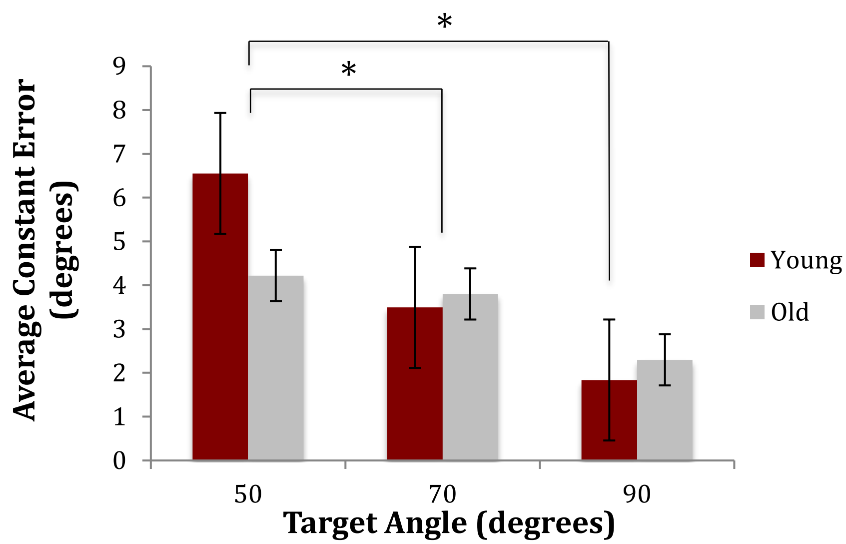

Figure 3. The effect of age (young, old) on average constant error (degrees) at three target angles (50°, 70°, 90°).

Variable Error

The ANOVA performed yielded no significant interaction between angle and age (p=0.376). There was also no significant influence of age on accuracy (p=0.106), nor was there significant influence of target angle on accuracy (p=0.106). Average variable error at each target angle and standard error of the mean is graphed for each age cohort (Figure 4).

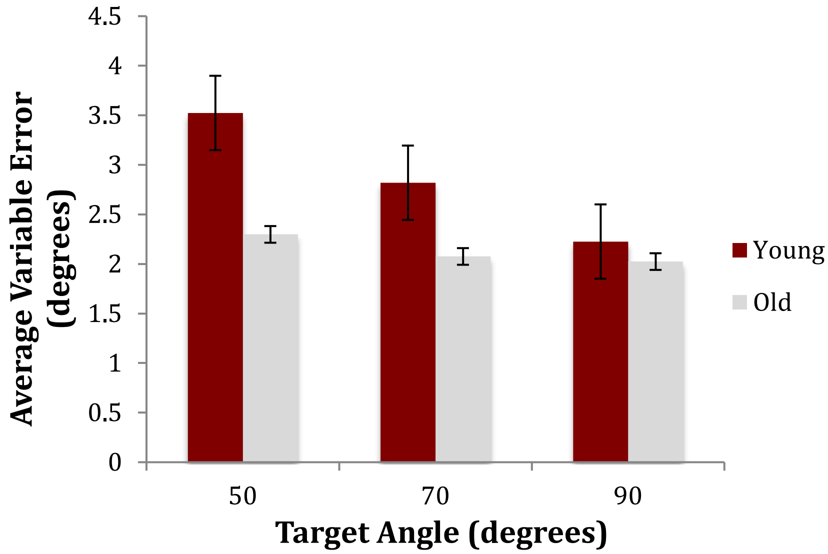

Figure 4. The effect of age (young, old) on average variable error (degrees) at three target angles (50°, 70°, 90°).

Discussion

The primary purpose of this experiment was to test the effect of age on shoulder joint proprioception. We represented proprioception with joint repositioning accuracy. We hypothesized that younger individuals would present with greater proprioception than older individuals. Contrary to this hypothesis, we found no significant influence of age on constant error ($p=0.456$) or variable error ($p=0.106$). The secondary purpose of this experiment was to test the effect of target angle on shoulder joint proprioception, again represented by joint repositioning accuracy. We hypothesized that proprioception would increase as target angle increased from 0° to 90° of joint flexion. The results yielded a significant influence of target angle on constant error ($p=0.001$) but not on variable error ($p=0.106$).

The aforementioned efference copy is a potential mechanism that contributed to these results. As previously mentioned, repeated stimulation of proprioceptors increases the proprioceptive information associated with the movement that is stored in the brain. This may help explain the relative consistency observed in the constant error values and variable error values across angles for the older cohort. Older age indicates more cumulative time to perform arm movement patterns, including shoulder flexion. With more time, the older cohort may have had more opportunities to perform shoulder flexion and increase their stored proprioceptive information associated with the movement.

This study does not conclude that any increased shoulder pain, instability, rotator cuff damage, or impingement in the older cohort is correlated with significant changes in shoulder joint proprioception. This does not mean that proprioceptive changes may not be correlated with such conditions experienced beyond the upper age boundary of this study. As previously mentioned, the occurrence of shoulder pain increases 5% from individuals aged 45-54 to 74-85 (Luime et al., 2004). Similarly, partial and full rotator cuff tears occur in 50% of individuals over the age of 50 and 80% of individuals over the age of 80 (Milgrom et al., 1994). This indicates that while the prevalence of such conditions increases with age, significant increases may not occur until ages beyond the scope of this study.

It also remains necessary to recognize that this study excluded individuals with previous shoulder surgery, shoulder joint macrotrauma, and shoulder joint pathology. It may be, then, that this experiment yielded insignificant proprioceptive differences because only healthy individuals were tested. Further, proprioceptive change may not be correlated with age, but rather with these conditions specifically. This determination would require further investigation of healthy and symptomatic subjects.

The significant influence of target angle on constant error demonstrated in this experiment supports prior research. Previous studies from the Orthopaedics Biomechanics Lab and beyond have demonstrated an increase in repositioning accuracy as shoulder flexion angle approaches 90° (Suprak et al., 2006; King et al., 2013; King & Karduna, 2013; Edwards et al., 2016). This study uniquely demonstrates that the influence of target angle on accuracy does not change with increased age. Also consistent with previous literature is the fact that target angle did not significantly influence the variable error (King et al., 2013).

The significant influence of angle on constant error may result from increased torque associated with the increasing external moment arm as shoulder flexion approaches 90° (Suprak, 2006). The increased accuracy may also result from heightened sensitivity of the Golgi tendon organs at musculotendonous junctions. Even still, it may result from altered alpha-gamma coactivation, articular proprioceptor activity, or sense of effort (King et al., 2013). These individual mechanisms may act independently or in tandem to produce the significant influence of angle on constant error.

Limitations

The results of this study may demonstrate a true lack of significant influence of age on proprioception. However, they may also reflect the limitations of the study. The most significant of these limitations is the small sample size. Regarding the 50° shoulder flexion angle, a sample size of at least 61 individuals would result in significant results if the observed data trends continued. Therefore, it is necessary to extend this protocol to at least 61 subjects to determine if the observed insignificance resulted from sample size or alternative factors.

The results may have also been skewed by the fact that the current study compares data from cohorts that were collected in two different settings. The protocol was nearly consistent between the two collecting conditions. However, different chair types were used in each protocol. The use of an ergonomic chair in the younger population removed the soles of the feet from the ground to ensure that shoulder proprioceptors be maximally isolated. The different chairs used between the cohorts also influenced posture in unique ways.

The two protocols also utilized different modes of auditory instruction. The younger cohort did not wear headphones. The older cohort used headphones to receive auditory instruction. These headphones may have dually provided clearer instruction to the older cohort and muted confounding sound in the environment. The younger subjects were situated in a lab adjoined by a noisy room, which may have caused distraction in the younger subjects and affected their ability to memorize and recreate the shoulder joint target angle.

An additional limitation is the small number of trials per angle. It was difficult to determine any outlying trials as each individual only completed 4 trials at each angle. The younger population more frequently presented with a single trial that seemed inconsistent with the remaining 3. This may have skewed the average constant error and variable error of the younger cohort compared to the older cohort.

A final limitation is the age ranges of each cohort. For this study, the older age cohort was restricted by the onset of age associated memory impairment, as we did not implement any sort of recall memory test before experimentation. As a result, the chosen age ranges may have been too similar to one another. This may have influenced the observation regarding significant proprioceptive changes in aging individuals.

Therefore, the most immediate follow up study to the presented protocol would be to increase the age of the older population and standardize headphone use across a sample of at least 61 individuals. Increasing the gap between the age cohorts would require a recall memory test prior to experimentation to exclude any subject with cognitive impairment. Increasing this age may more thoroughly answer the question of whether or not age affects proprioception, as the current study may have been too narrow in its timespan. The standard use of headphones may help eliminate distraction in each age cohort and more accurately answer the primary question. Sample of 61

Conclusion

This study did not yield a significant difference between age and shoulder joint proprioception as represented in shoulder joint repositioning accuracy. Consistent with previous research conducted in the lab, this test did yield a significant difference between angle and shoulder joint repositioning accuracy. It may be true that no proprioceptive difference exists between any two ages. However, it may be that there is simply no significant difference between the age ranges utilized in this study. Continuation research is necessary to determine if proprioceptive changes correlate with acquired shoulder syndromes and injuries.

Appendix

Research Compliance Services
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University of Oregon Department of Human Physiology
Informed Consent for Participation as a Subject in
"Motion Analysis with the iPhone and iPod Touch"
Investigator: Andrew Karduna, PhD

Introduction
You are invited to participate in a study conducted by Dr. Andrew Karduna from the University of Oregon to study joint motion.
You were selected as a possible participant because you are generally in good health.
Please 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 investigation is to study proprioception (awareness of limb position). 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 will ask you to do the following things:
A device (iPod) will be attached to your arm or leg. With your eyes closed, you will receive auditory cues to move your limb until a target position is reached. You will be asked to keep your limb in that position and then return to the initial position. You will then be instructed to return to the same position. You will be asked to repeat this task several times. The entire protocol will take less than 30 minutes.

Risks/Discomforts of Being in the Study
The study has the following risks: although you may experience some minor discomfort from the iPod being attached to your limb, this will resolve once the device is removed.

Benefits of Being in the Study
The purpose of the study is to investigate proprioception. There is no direct benefit to you by participating in this study. However, that information gained in this study may help health care professionals and scientist understand joint function.

Payments
You will receive no reimbursement for participating 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.

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Research Compliance Services
10/16/2017-02/27/2018
"APPROVED"

Figure 5: Subject consent form (page 1 of 2).

UNIVERSITY OF OREGON

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

In the unlikely event that 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 Dr. Andrew Karduna. 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 Dr. Karduna 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 asked if you want to be given a copy of this form to keep for your records and future reference.

Statement of Consent

I have read (or have had read to me) the contents of this consent form and have been encouraged to ask questions. I have received answers to my questions. I give my consent to participate in this study. I have been asked if I want a copy of this form.

Signatures/Dates

____

Study Participant (Print Name)

____

Participant Signature **Date**

Page 2 of 2

Figure 6. Subject consent form (2 of 2).

Subject Intake Form

Project: Motion Analysis with the iPhone and iPod Touch

Name _____________________ Subject Code ___________________

Date _______________ Dominant Side _________

Weight __________ Height ___________

Age ________ Gender _________

History of joint injury ____

Current Joint Pain ____

Sports participation:____

Ethnic Category (optional)

Check One:

_____ Hispanic or Latino

_____ Not Hispanic or Latino

_____ Unknown or Not Reported

Racial Categories (optional)

Check One:

_____ American Indian/Alaska Native

_____ Black or African American

_____ Asian

_____ Native Hawaiian or Other Pacific Islander

_____ White

_____ More Than One Race

_____ Unknown or Not Reported

Figure 7. Subject intake form, completed prior to experimentation.

How to determine dominant hand:

1.) Which hand do you write with?

2.) Which hand do you hold a fork or spoon with?

3.) Which hand do you throw a ball with?

4.) Which hand do you catch a ball with?

5.) Which hand do you pick up a water bottle on the table with?

6.) Which hand do you hold scissors in to cut a piece of paper?

7.) Which hand do you pick up a heavy object with?

If the answer to the majority of these questions is "right," the subject is right hand dominant for the sake of the experiment.

If the answer to the majority of these questions is "left," the subject is left hand dominant for the sake of the experiment.

Figure 8. Questions used to determine dominant upper extremity in young cohort subjects.

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