

AUTONOMOUS DATA COLLECTION IS AS EFFECTIVE AS
LABORATORY-BASED DATA COLLECTION USING A
JOINT POSITION SENSE APPLICATION

by

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A THESIS

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Collection Using a Joint Position Sense Application

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Andrew Karduna, PhD

Proprioception is the unconscious awareness of body position and motion in space that enables the freedom of daily physical tasks. A submodality of proprioception, joint position sense, is an important clinical metric that has previously been assessed in both passive and active protocols. Recently, our laboratory has shown that joint position sense assessed using an active repositioning task can accurately be measured using a smartphone application. However, a visit to a laboratory is still required, which can be time-intensive and expensive. The objective of this study was to demonstrate that autonomous measurement using a joint position sense application is as consistent and reliable as laboratory-based measurement. We recruited 20 healthy subjects from the University of Oregon. Our results demonstrated no main effect of condition, and similar patterns to what has been measured in the past - repositioning errors decrease with increasing shoulder flexion angles. These results show promise for future protocols to implement autonomous measurement when assessing joint position sense.

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Introduction

Proprioception

Proprioception is the awareness of body position and motion in space without visual stimuli (King and Karduna, 2014). This sense is important for the functionality of daily living tasks, including conscious movement and unconscious reflexes.

Proprioception is categorized as a combination of joint position sense (JPS), the ability to perceive the position of a limb in space, kinesthesia, the ability to perceive limb movement, and force sense (Aydin et al., 2001). In our lab, we have designed protocols to measure the JPS submodality.

Proprioceptive information is relayed from musculotendinous, capsuloligamentous, and cutaneous mechanoreceptors to the central nervous system, which utilizes the sensory information to help the body produce smooth movements (Myers et al., 2003). Specifically, the nervous system induces muscular adjustments that can assist movement, and minimize the chance of joint injury (Blasier et al., 1994). The primary contributors to JPS are musculotendinous mechanoreceptors, the muscle spindle fibers and golgi tendon organs (Janwantanakul et al., 2001). Muscle spindles are located in the muscle belly and detect changes in length of a muscle as a result of muscle stretch (Matthews, 1964). Golgi tendon organs are located in tendons and detect changes in muscle tension (Jami, 1992). When activated, muscle spindles and golgi tendon organs send afferent signals via Ia and Ib sensory fibers respectively to the central nervous system (Proske and Gandevia, 2012).

Shoulder Anatomy and Movement

JPS has been measured at a variety of joints, including the shoulder (Suprak et al., 2006), elbow (Brockett et al., 1997), knee (Skinner et al., 1986), and ankle (Heit et al., 1996). In the past, our lab has measured JPS at the shoulder. The shoulder joint, or glenohumeral joint, is a ball and socket joint between the scapula and the humerus. The glenohumeral joint is heavily utilized by all demographics for daily functional use, and more demanding athletic skills.

The glenohumeral joint is capable of a range of movements, including abduction/adduction (frontal and transverse planes), flexion/extension, medial/lateral rotation, and circumduction. For this study, JPS will be measured during shoulder flexion. Shoulder flexion is humerothoracic motion from anatomical position. This movement occurs in the sagittal plane and is produced by the pectoralis major, deltoid, biceps brachii, and coracobrachialis (Moore et al., 2014).

Suprak et al. (2006) previously demonstrated that shoulder JPS improves with elevation angle. The study measured JPS with subjects performing shoulder elevation in the scapular plane, and found that JPS improves going from 30° to 90° target angles. It is not fully understood why this trend occurs. One prior hypothesis was that at higher elevation angles, JPS may be enhanced due to increased muscular activation levels. Increased muscular activity directly correlates with increased afferent feedback from muscle spindles and golgi tendon organs. As such, the body has a better awareness of limb position. However, this was later disproven in a body orientation study (Chapman et al., 2009). Higher torque at lower elevation angles did not result in improved JPS at lower elevation angles.

JPS Measurement

JPS can be measured in a variety of ways. Recent measurement has utilized an active limb positioning and active limb repositioning method (King et al., 2013). In an active protocol, movement is affected by the subjects themselves, aided only by auditory or visual cues for positioning to a target angle. After subjects are directed to a specific target angle, they then attempt to reposition their limb to that position in the absence of the sensory cue. The difference in angle between the initial position and the reposition directly corresponds to JPS performance.

Several types of instrumentation have been used to measure JPS in the past, including laser pointers, goniometers, and inclinometers (Vafadar et al., 2015). More complex instruments include electromagnetic tracking devices and motion capture systems. Some limitations of these approaches are that they require extensive setup, a visit to a laboratory, and can be expensive to use. A methodological solution to these limitations is to measure JPS using mobile applications. Mobile applications are completely wireless, making setup a more efficient process. Mobile applications are also more economical than traditional instruments such as electromagnetic tracking devices and motion capture systems. A JPS measurement application has been developed for iOS devices. This application takes advantage of the technologies available in modern mobile devices to generate accurate and reliable JPS data. Edwards et al. (2016) used the JPS application to assess joint position sense in a field based setting. The results of that study matched a similar pattern to what has been measured using a Polhemus motion capture device; which was a decrease in angular errors with

increasing shoulder flexion angles. That study demonstrates that the use of mobile applications is a reliable method for assessing JPS.

JPS measurement is clinically an important tool. Studies has shown that proprioceptive defects can lead to muscular or ligamentous injuries (Lephart and Henry, 1996). These injuries can damage proprioceptive receptors, and potentially increase the likelihood of further injury. Measuring and assessing proprioception is thus a preventative strategy against injury. It can also be used as a diagnostic tool, by assessing patients' proprioception over time during recovery.

Autonomous Data Collection

A review article by Mourcou et al. (2015) discusses how the advent of smartphone technology has paved the way to replace costly clinical tools to measure JPS such as goniometers, scoliometers, laser-pointers, and inclinometers. Smartphones contain modern and standard technologies including 3D accelerometers, magnetometers, gyroscopes, screen displays, audio systems, and tactile feedback systems. Despite the advancements in mobile technology, the authors note a lack of studies on smartphone tools allowing for autonomous measurement, specifically in relation to JPS measurements.

There are several advantages of autonomous measurement. A study by Algar and Valdes (2014) discusses how smartphones can be used as hand therapy interventions. The authors explain how applications can bring solutions to clinicians for patient rehabilitation. For example, applications can provide wrist proprioceptive and joint sense exercises which patients can perform autonomously. Use of smartphone applications for rehabilitation has also been compared with traditional home-based

rehabilitation in patients with post-myocardial infarction (Varnfield et al., 2014). The study found that smartphone-based home care improved “post-MI CR uptake, adherence and completion”, thus demonstrating the clinical effectiveness of smartphone applications in autonomous rehabilitation. Autonomous measurement with smartphones also addresses the aforementioned limitation of traditional JPS instrumentation, which is the necessity of a laboratory visit. From the perspective of a researcher, autonomous measurement is an efficient process which expands the potential subject pool. From the perspective of a subject, autonomous measurement eliminates the time commitment of a laboratory visit.

One limitation of using smartphones for autonomous measurement and rehabilitation purposes is reaching the full target market. This ability may be limited due to lack of knowledge on the application and/or lack of resources to obtain the application (older phone technology that does not support the application). For example, an application designed to prevent ankle sprains (Vriend et al., 2015) reached only 2.6% of its projected target population. However, this demonstrates the need that more research on smartphone autonomous measurement needs to be done in order to assess and improve the usability of mobile applications. This process could potentially help expand targeted markets.

Purpose of this Study

Previous studies have demonstrated the feasibility of using mobile devices to assess JPS in a field-based setting. The objective of this study is to determine the efficacy, specifically the consistency and reliability, of using mobile devices to autonomously collect JPS data. The results of this study will give insight as to whether

JPS applications built for mobile devices are accessible to users outside the realm of biomechanics. In essence, the absence of a laboratory representative is meant to mimic real-world situations in which individuals download a JPS application on their own mobile device and are expected to understand operational functions with the information local to the application. We hypothesize that the autonomous data will be reliable. We also hypothesize that there will be no significant difference between conditions for constant error and variable error. Lastly, we hypothesize that constant error and variable error would decrease going from low to high target angles.

Methods

Subjects

Twenty healthy adults (10 female, 10 male) were recruited from the University of Oregon community. Subjects had a mean age of 21.1 ± 0.9 years, mean height of 1.7 ± 0.1 meters, and mean mass of 66.5 ± 14.8 kilograms. Seventeen subjects were right-handed; three subjects were left-handed. Subjects were excluded if they: 1) had prior shoulder joint surgery; 2) had macrotrauma to the shoulder joints; 3) or had a disease affecting shoulder joint function. Subjects reported to a single testing session lasting 20-30 minutes. Upon arriving, subjects filled out an intake form and signed an informed consent form approved by the Institutional Review Board at the University of Oregon. The intake form collected basic demographic data and the informed consent form outlined the protocol, risks, benefits, and disclaimers of the study (see Appendix).

Instrumentation

The iOS application, Joint Position Sense, was downloaded to a 4th generation Apple iPod Touch (6 cm x 4 cm x 0.6 cm) to assess active joint repositioning. The application was designed by the Orthopaedic Biomechanics Laboratory at the University of Oregon and developed by the University of Oregon InfoGraphics. The application utilized two sensors found in the iPod Touch, the 3-axis gyroscope and accelerometer. The angle of the device with respect to gravity was calculated from the accelerometer data, as has been previously done with an ambulatory tri-axial accelerometer (Amasay et al., 2009). The iPod Touch was inserted into the pouch component of a sports armband; two extender straps on the armband were used to attach

the device on the long axis of the subject's humerus. Audio was played through the internal speakers of the device.

A 2 minute 28 second video outlining the experimental procedure was shown on a 13-inch MacBook Pro. Audio was played through the internal speakers of the laptop.

A summary of the video content is shown in Table 1 below.

Time	Description
0:00 - 0:18	Opening the JPS application.
0:18 – 0:27	Entering the user ID and selecting the test.
0:27 – 0:45	Putting on the armband.
0:45 – 1:32	Using the application and protocol.
1:32 – 2:21	Sample trials.
2:21 – 2:28	End of session instructions.

Table 1: Summary of Video Content

The first column denotes the starting and ending time of the specific segment being shown. The second column denotes a description of each segment.

Procedure

The protocol used in this study is a modification of a protocol from our lab in which a magnetic tracking device was used to record kinematics (King et al., 2013).

This study aimed to examine autonomous and laboratory-based data collection of JPS at

the shoulder. Therefore, in the first set of trials, subjects collected data without the presence of a laboratory representative. To collect data, subjects were given an iPod Touch with the JPS application pre-installed. The settings for the application were pre-set and are outlined in Table 2 below.

Metric	Setting
Target Angular Uncertainty	2 degrees
Relaxed Angular Uncertainty	10 degrees
Target Hold Time	3 seconds
Reposition Hold Time	1 second
Initial Hold Time	3 seconds
Relaxed Hold Time	2 seconds
Angular Velocity Average Time	0.25 seconds
Angular Velocity Uncertainty	5 degrees/second

Table 2: JPS Application Settings

The first column denotes the name of the pre-set metric. The second column denotes the value of the setting and its corresponding unit.

To ensure a first-time user experience with the application, the autonomous trials were always tested first with each subject. The only information that was given to subjects

was through a short video (Figure 1) that demonstrated the experimental protocol (see Table 1) which they then were expected to replicate. After subjects completed watching the video, the researcher left the room and the subjects began the protocol.



Figure 1: Watching the Protocol Video

Subjects learned how to conduct the protocol by watching a video on a 13-Inch MacBook Pro. Subjects were given the option to watch the video multiple times.

Subjects first opened the application and then entered their user ID. User ID's were written on intake forms and the laboratory representative prompted subjects to memorize that code prior to watching the video. Next, they selected the pre-set test which left them at a "Start" screen. At this point, subjects inserted the device into a sports armband and then attached the armband to the lateral side of their dominant humerus. The next step was to get in the relaxed seated position; subjects had their feet flat on the ground and their back straight (Figure 2).



Figure 2: Relaxed Seated Position

In the relaxed position, subjects have their eyes closed, hands to their side, back straight, and feet flat on the ground.

Once subjects were in the seated position, they clicked “Start” on the device, returned their arms to their side, and closed their eyes. Subjects were then prompted to shoulder flex to three target angles (50° , 70° , and 90°) with the aid of auditory feedback from the JPS application (Figure 3).



Figure 3: Guided Shoulder Flexion

Subjects elevate their shoulder based on auditory feedback in the guided task.

The application aids movement to a target angle by using different frequency tones to indicate that the subject is outside the target range. A low frequency tone indicates that the shoulder is below the target angle, while a high frequency tone indicates that the shoulder is above the target angle. No sound is heard when the shoulder is within ± 2 degrees of the target angle. Subjects hold their target positions for two seconds, which gives them time to memorize their position. After two seconds, a verbal “relax” cue is given by the application and subjects can return their arms to their side. There is a three second break before subjects must find the target angle they memorized when they are given a verbal “find target” cue, without the aid of auditory feedback. Subjects are automatically prompted by the application to continue the remaining trials. During shoulder flexion, subjects kept their elbows locked and thumbs pointed upward. Target positions were randomized and each target position was presented three times, for a total of nine trials. At the end of the session, a verbal “end of session” cue was given by the application. Subjects removed the device from their shoulder and the laboratory representative re-entered the testing room.

The next set of trials were conducted under laboratory representative supervision. The device and armband were first repositioned on subjects’ arms. Subjects were then asked to demonstrate shoulder flexion several times so that the laboratory representative could assess whether they were maintaining proper movement. The laboratory representative corrected subjects when proper movement or posture was not maintained. Subjects were then asked to run through the same protocol with one minor distinction. Rather than the subject opening the app, entering the correct start-up

settings, and clicking “Start”, the laboratory representative assumed all those duties. An alternative user ID was entered to collect the new data.

Data Analysis

All data collected from the autonomous and supervised trials were stored internally on the iPod Touch. Data was transferred to a computer and then processed in LabVIEW (National Instruments, Austin, TX) (Figure 4).

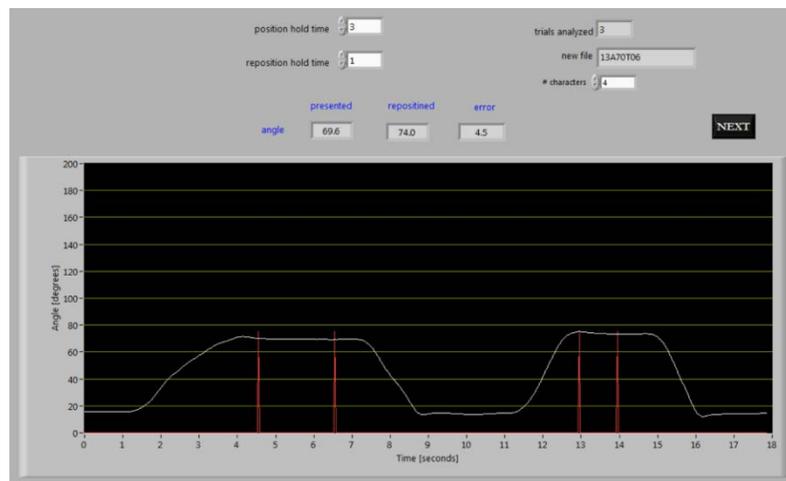


Figure 4: LabVIEW Analysis

Sample waveform of 70 degrees shoulder flexion.

The software outputs a waveform which shows the change in angle of the device with respect to time. The data were visually inspected to ensure that all trials were completed fully and accurately. An ideal waveform has two spikes in angle, one for the presented angle and the other for the repositioned angle. Each spike represents the mean angle during the hold time. The software subtracts the presented angle from the repositioned angle to generate repositioning error. A positive repositioning error indicates that the subject overshoot the target angle (second spike greater than the first spike). A negative repositioning error indicates that the subject undershot the target angle (second spike

lesser than the first spike). All trials that are processed at once through LabVIEW are compiled in an Excel document which lists the presented angle, the repositioned angle, and the repositioning error. For each condition, repositioning error was averaged at each target angle to calculate constant error. Variable error was calculated using the

following equation: $\sqrt{\frac{\sum(X_i-M)^2}{N}}$. Constant errors and variable errors were used for

analysis (Edwards et al., 2016).

Statistical Analysis

SPSS version 22.0 (IBM, Chicago, IL) was used for statistical analysis. Two-way repeated measures analysis of variance (ANOVA) was performed with condition (autonomous, supervised) and angle (50°, 70°, and 90°) as the independent variables and constant error as the dependent variable. Follow-up paired t-tests were performed when a significant main effect for angle was found with the ANOVA; the α was designated at 0.05. Comparisons were performed using a Bonferroni correction. A mixed model intraclass correlation coefficient (ICC(2,3)) was performed to test the reliability of the JPS application measurements when used autonomously by subjects and when used under laboratory supervision.

Results

Constant Error

The results of the ICCs indicate varying reliability for different target angles. The ICC value for 50° was 0.71, 70° was 0.59, and 90° was 0.87.

There was no interaction effect between conditions ($p = 0.92$). The ANOVA identified no significant main effect of condition on constant error ($p = 0.66$). There was a significant main effect of angle on constant error ($p = 0.002$).

To determine which target angles were significantly different, paired t-tests were performed between 50°-70°, 50°-90°, and 70°-90°. The tests revealed a significant difference between 50°-70° ($p = 0.003$) and 50°-90° ($p = 0.029$). There was no significant difference between 70°-90° ($p = 0.99$). Average constant error at each target angle for both conditions is shown below (Figure 5).

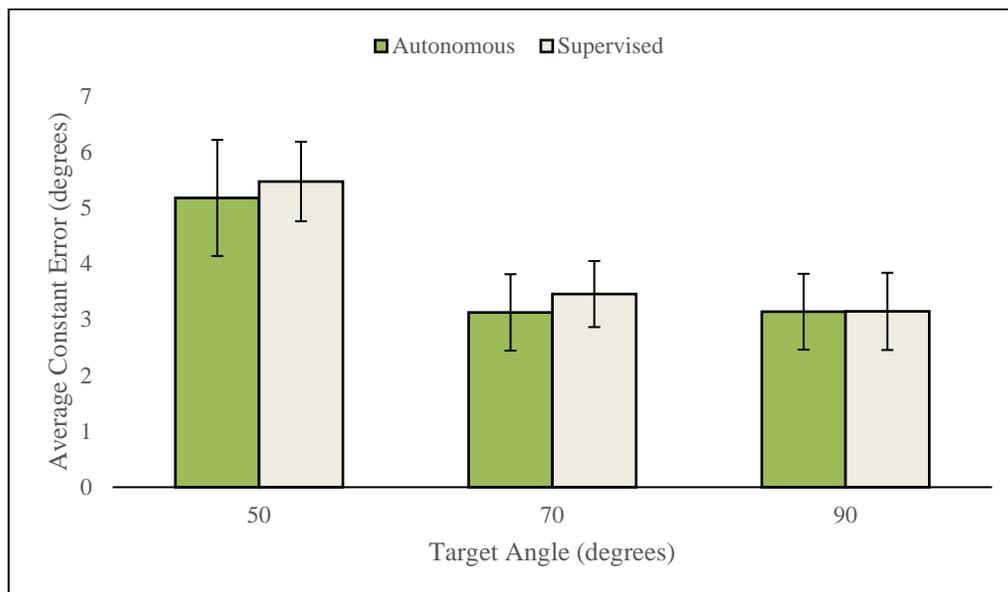


Figure 5: Average Constant Error Autonomous/supervised average constant errors. Error bars: standard error of the mean.

Variable Error

There was no interaction effect between conditions ($p = 0.59$). The ANOVA identified no significant main effect of condition on variable error ($p = 0.064$). There was a significant main effect of angle on variable error ($p = 0.001$).

To determine which target angles were significantly different, paired t-tests were performed between 50°-70°, 50°-90°, and 70°-90°. The tests revealed a significant difference between 50°-70° ($p = 0.01$) and 50°-90° ($p = 0.015$). There was no significant difference between 70°-90° ($p = 0.99$). Average variable error at each target angle for both conditions is shown below (Figure 6).

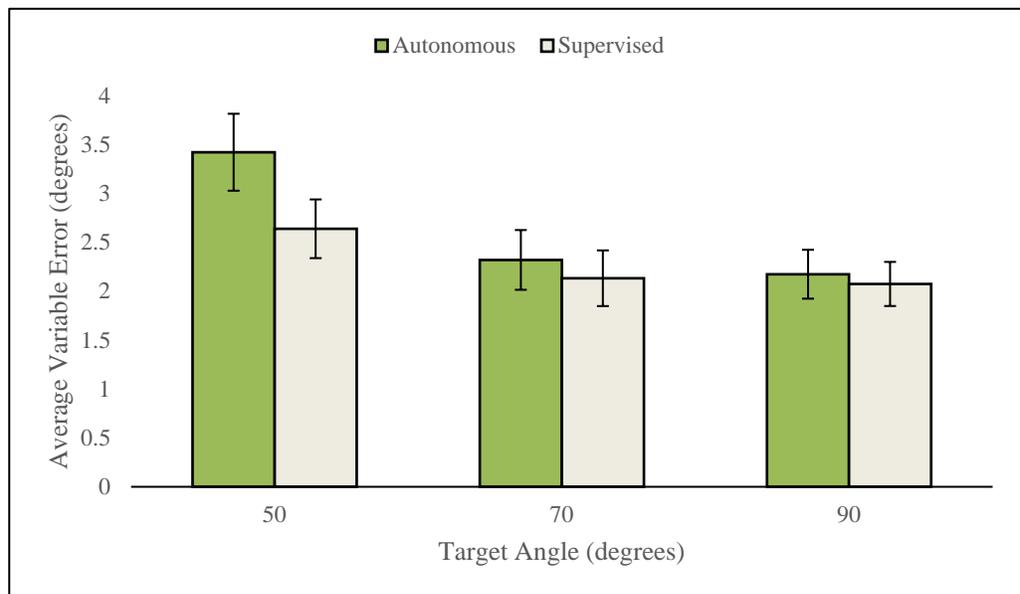


Figure 6: Average Variable Error

Autonomous/supervised average variable errors. Error bars: standard error of the mean.

Discussion

The purpose of the study was to determine whether subjects could assess JPS data autonomously. We hypothesized that the autonomous data would be reliable. We also hypothesized that there would be no significant difference between conditions; whether subjects collected data on their own or if they were supervised. We lastly hypothesized that constant error and variable error would decrease going from low to high target angles.

We found no interaction effect or main effect of condition for either constant error or variable error. The data subjects collected autonomously did not differ significantly from the data collected when subjects were supervised. We also conducted intraclass correlation coefficients (ICCs) to describe how closely the results from each condition resembled one other. For constant error, we observed a range reliability scores - reliability varied based on target angle. For this analysis, the parameters 0.4-0.75 and >0.75 represent “fair to good reliability” and “excellent reliability” respectively (Lexell and Downham, 2005). The ICCs indicate a fair to good reliability for 50 and 70 degrees, and excellent reliability for 90 degrees. These scores imply a strong repeatability between constant error values in each condition.

These analyses indicate that the autonomous data is reliable. An equally important question is whether the data is consistent. We can specifically compare our results to a previous study done in our lab, in which we tested JPS at the shoulder using the mobile application (Edwards et al., 2016). Consistent with that study, we found a main effect of target angle on constant error and variable error. Our follow-up t-tests revealed that repositioning errors at 50 degrees were significantly larger than

repositioning errors at 70 degrees and 90 degrees. There was no significant difference in repositioning error between 70 degrees and 90 degrees. The general shape of response also matches a study in which we used a traditional electromagnetic tracking device to measure JPS at the shoulder (King et al., 2013). We expect significantly smaller repositioning errors at larger shoulder elevation angles. This trend is not fully understood. One explanation is that high muscular effort and tendon tension contributes to activation of muscle spindle and golgi tendon organ afferent signals (Suprak et al., 2006). We also expect subjects to deviate less at higher target angles (constant error), and be more consistent at higher target angles (variable error) (Edwards et al., 2016).

There are several important applications of the findings from the present study. Autonomous data collection allows researchers to expand their subject pool. All that is required is for subjects to be able to download an application on their device, and have specific directions on how to conduct the protocol. Potentially, data could be collected from any location, without requiring physical supervision by researchers. For studies which report high variation in results due to small sample size, a protocol which utilizes autonomous measurements may be an effective way to increase samples sizes. In addition to increasing sample size, researchers can collect data from many different demographics. Autonomous data collection may be a more convenient method for subjects and patients. For example, it may be inconvenient for an athlete going through rehabilitation due to an injury to travel to a sports clinic to undergo proprioceptive tests. Rather, the tests could be conducted at home and the data could be sent to a clinic to be analyzed. In this way, doctors could monitor their patients in real-time without having to physically be with them. Overall, our methodology takes advantage of the growing

capabilities of smartphone technology, and paves the way for future scientific studies to optimize and improve their protocols.

Limitations

One limitation of the present study includes the age distribution of the subject pool. Our subject population consisted solely of students from the University of Oregon (ages ranging from 20 to 23 years). It is equally important to consider if autonomous measurement of proprioception is practical in other demographics. For example, studies have shown that proprioception is more important than vision to maintain balance in elderly people (Ribeiro and Oliveira, 2011; Hay et al., 1996). Furthermore, proprioceptive physical activities have been shown to improve balance control in elderly people (Gauchard et al., 1999). Therefore, proprioceptive tests may be relevant for elderly populations, and correlatively studies assessing autonomous data collection in those populations. It would be incorrect to assume that the results of this study translate to other demographics as the ability to use smartphone technology may vary across populations.

Another limitation of this study is that it solely relies on the use of video to communicate the protocol to subjects. Studies suggest that there are significant cognitive performance differences when processing the meaning of videos or pictures compared to words (Thierry and Price, 2006). In some situations, clinicians or researchers utilize text to communicate a procedure. In these instances, it may be useful to know if data can be collected autonomously if patients or subjects are given information in a variety of ways, including a text format.

Finally, the present study had a relatively small sample size. A total of 20 subjects completed the study. A potential benefit of autonomous data collection is that the size of subject pools could be increased; an affirmation of this idea would be testing a larger subject population and gathering similar results. Additionally, it is possible that the small sample size contributed to a higher variability in constant/variable error at each target angle.

Future Studies

The primary objective of this study was to evaluate the efficacy of autonomous data collection using a JPS application. This study assessed JPS at the shoulder; future studies should implement autonomous data collection at different joints. JPS has been measured at a variety of joints, and autonomous data collection may be a viable method for these protocols. Since protocols vary in a variety of ways, including the method of putting on the mobile device, user inputs on the application, and joint movement, it would be useful to know the extent to which autonomous measurement can be used to collect JPS data.

Work on smartphone-based systems is in an effort to make joint movement and sensorimotor control studies cost-effective and efficient. Future studies should take advantage of the growing capabilities smart-devices. A potential area of research is the use of wearable technology to collect JPS data. One form of wearable technology, smartwatches, contain many of sensors found in smartphones, including accelerometers and gyroscopes. Advantages of smartwatches are that they are compact and lightweight. These attributes minimize the potential confound of added weight on a joint and ability

to reposition an angle. Many smartwatches also contain Wi-Fi and Bluetooth; thus, applications could be programmed to instantly transfer data to a connected device.

This protocol was designed to mimic at-home measurements. The most immediate follow-up to this study would be to have subjects download the JPS application on their own devices, and conduct the protocol at their homes. Data could then be transferred via Dropbox, and compared to the results of this study. In this manner, hundreds of subjects could potentially be tested, allowing for reliable and cost-effective large-scale studies.

Conclusion

Here we have shown that autonomous data collection is as effective as laboratory-based data collection using a joint position sense application. We define effectiveness by the consistency and reliability of the data. We found no interaction effect or main effect of condition on constant error or variable error. The ICC values at each target angle were high, suggesting that reliable JPS data can be collected autonomously. Our follow-up t-tests revealed that repositioning error is significantly higher at 50 degrees, compared to 70 degrees and 90 degrees. This trend is consistent with previous studies done in our lab (King et al., 2013; Edwards et al., 2016). Future studies should take advantage of the growing capabilities of smartphone technology and implement autonomous-based measurement into their protocols.

Glossary

Accelerometer: a device which measures an object's physical acceleration.

Active Movement: movement performed by an organism itself.

Afferent Signal: sensory impulse that is transmitted to the central nervous system.

Central Nervous System (CNS): nerve tissues which control the body.

Constant Error: measure of the deviation from a target.

Flexion: bending of a joint in a limb.

Glenohumeral Joint: ball and socket joint involving the humerus and the glenoid cavity.

Golgi Tendon Organ: sensory receptor which detects change in muscle tension.

Gyroscope: a device which measures an object's orientation.

Interaction Effect: independent variables effect different experimental outcomes.

Intraclass Correlation Coefficient (ICC): how strongly values resemble each other.

Joint Position Sense (JPS): awareness of limb position in space.

Kinesthesia: awareness of limb movement in space.

Mechanoreceptor: sensory organ that reacts to mechanical stimuli.

Muscle Spindle Fiber: sensory receptor which detects change in muscle length.

Paired T-Test: determines statistical significance between two means.

Proprioception: awareness of body position and movement in space.

Repositioning Error: difference between positioned angle and repositioned angle.

Standard Error of the Mean (SEM): estimates the variability between samples.

Two-Way Repeated Measures Analysis of Variance (ANOVA): statistical test for repeated measure designs, dealing with two categorical independent variables.

Variable Error: measure of consistency to a target.

Appendix

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) **Racial Categories (optional)**

Check One: Check One:

____ Hispanic or Latino ____ American Indian/Alaska Native

____ Not Hispanic or Latino ____ Black or African American

____ Unknown or Not Reported ____ Asian

 ____ Native Hawaiian or Other Pacific Islander

 ____ White

 ____ More Than One Race

 ____ Unknown or Not Reported

Figure 7: Subject Intake Form



**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 10-15 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.

Figure 8: Informed Consent Form (Page 1)

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