Reliability of Image Capture Technique for the Measurement of Upper Limb Active Joint Position Sense in Healthy Adults

Iraj Abdollahi1, Elnaz Allahverdloo1

Objective
Proprioception is the conscious perception of limb position, motion, balance, and pressure. It has a vital role in movement control, especially motor planning and neuromuscular feedback mechanisms. To investigate the proprioceptive function, it is essential to use the best measurement method. Different techniques and approaches have been introduced, which are usually expensive and not applicable for clinical use. One of these methods is the image capture technique which is easy and practical. Stillman introduced this technique to measure the joint position sense of the knee considering all variables affecting it and reported its good reliability. Many studies have used this technique for knee and lower limb joints and reported its good reliability, while few studies have used this technique for upper limb joints. Therefore, this study investigates the reliability of the image capture technique for measuring the Active Joint Position Sense (AJPS) of the left shoulder and elbow in healthy adults. If it yields a good result, it can be used as an available and cost-effective method by clinicians.

Materials & Methods
In this methodological study, the participants were 10 healthy adults (5 men, 5 women) aged 18-40 years. To assess the AJPS, we used image capture technology which is one of the most reliable methods for the lower limb joint position sense measurement. Markers were attached on elbow and shoulder landmarks, and photos were taken during the reproduction of angles by participants. Then, the photos were entered into AutoCAD software, and the angles were calculated by drawing line segments from landmarks and connecting them. The absolute error and relative error (the difference between the initial and reproduced angles) were used to measure accuracy. The AJPS was assessed for internal and external rotation of the shoulder and elbow flexion. The measurements were repeated two hours later to assess intra-day reliability and two days later to assess inter-day reliability. Interclass Correlation Coefficient (ICC) and Standard Error of Measurement (SEM) were used for statistical analysis.

Results
The ICC of inter-day reliability of the test for all shoulder and elbow movements in relative and absolute errors was reported as excellent (≥0.92). Intra-day reliability was reported excellent (≥0.90) for elbow flexion, and internal rotation of the shoulder in both relative and absolute errors were excellent (0.94). For external rotation of the shoulder, it was excellent in relative error (0.94) and good in absolute error (0.80). All measurements had absolute reliability based on the SEM results.

Conclusion
The image capture technique is a simple, cost-effective, and available method tool for measuring AJPS and proprioception in upper limbs by clinicians and researchers.

Keywords:
Proprioception, Joint position sense, Upper limb, Image capture technique

ABSTRACT

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Corresponding Author:
Elnaz Allahverdloo, MSc.
Address: Department of Physiotherapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.
Tel: +98 (901) 2681077
E-Mail: elnazallahverdloo@gmail.com
Extended Abstract

Introduction

Proprioception is the conscious and unconscious perception of limbs, joint position, sense of movement, and sense of force [1]. Joint proprioception arises from a set of different messages from muscle mechanoreceptors, tendons, joint capsules, ligaments, and skin. The receptors involved in proprioception include muscle spindles and the Golgi tendon organ [2, 3]. These muscle-tendon receptors transmit information about the static length of the muscles, the change in muscle length, and the force produced by the muscles to the central nervous system [4]. Given that most of the mechanoreceptors associated with proprioception are active at the end range of motion of a joint, the muscle spindle plays a unique role in transmitting proprioceptive messages [5].

For this reason, static proprioception tests are not practical enough because inactive movements do not stimulate the muscle spindle, which is a very sensitive mechanoreceptor [6]. Studies have shown that after damage to the joint capsule, ligament, labrum, or muscles involved, the proprioception gets impaired [7-10]. Damage to the tissues that contain mechanoreceptors causes a relative reduction in afferent messages, which can lead to impaired proprioception and make a person prone to re-injury due to a decrease in proprioceptive feedback [11]. Proprioception and vision together play a special role in controlling movements [12]. Therefore, it is imperative to study proprioception to rehabilitate and prevent re-injury [13, 14] properly.

Joint position sense, which is one of the components of proprioception, is a measure of the ability to reproduce a joint angle accurately. This sensation is done actively and passively, and the amount of angle error is a good criterion for measuring the sense of joint position [15]. To measure the joint position sense, various tools and methods, such as electrogoniometer, Biodex machine [16], inclinometer, motion analyzer [17], isokinetic dynamometer [18], and image capture technique [19] have been used. However, these methods are expensive and specialized. Also, they require a lot of space and are unusable in medical settings. Stillman first proposed the image capture technique in 2000 [6]. Unlike other methods, it does not require complex tools and is not limited to use in laboratories. Smith et al., in a review study by Ager et al. on different methods of measuring the sense of active and passive shoulder joint position, the dynamometer showed the highest reliability (0.92), and the image capture technique had the highest reliability (0.81) for measuring the sense of passive shoulder joint position [20]. Because of the differences in the joints of upper and lower limbs, where the lower limbs are for weight-bearing and walking, and the upper limbs are for movement and delicate tasks, studies are needed to evaluate the reliability of image capture technique for the upper limb joints. Therefore, this study aims to evaluate the reliability of the image capture technique for measuring Active Joint Position Sense (AJPS) in upper limbs to be used as an accessible and usable method in clinics.

Materials and Methods

This research is a methodological study. By using a convenience non-probability sampling method, 10 healthy individuals (5 females and 5 males) aged 18-40 years [25] were selected from the students of the University of Social Welfare and Rehabilitation Sciences in Tehran, Iran, in 2019. The sample size was determined according to Relph et al. [21] and using Equation 1. The study process was explained to the participants, and they completed a form containing personal information and signed a consent form to participate in the study. The inclusion criteria were being right-handed (In healthy right-handed people, proprioception in the non-dominant hand is more accurate [25] and no left upper limb injury in the past 6 months [6].

\[
\text{var} \hat{p}_i = \frac{2(1-\hat{p}_i)^2(1+(k-1) \hat{p}_i)^2}{k(k-1)(n-1)} , n = 8 \frac{8(1-\hat{p}_i)^2(1+(k-1) \hat{p}_i)^2}{k(k-1)} \text{var} \hat{p}_i + 1
\]

The subjects attended two similar test sessions two days apart. In each session, the AJPS of the left shoulder and elbow was measured through active reproduction of angles and using the image capture technique. The joints were examined in random order, and the participants were asked to guess the order of shoulder or elbow joint measurements without knowing the contents of the sheets in the envelope. To measure each joint, the respective landmarks were first identified with black circular markers (2-cm diameter). Then, a 16-megapixel digital camera was placed at a distance of 1 m and aligned with the joint level.

The measurement of the AJPS of the elbow was done while the patient was sitting on a chair without an armrest.
and with closed eyes. Elbow landmarks were affixed to the outer edge of the acromion, lateral epicondyle, and between the distal radioulnar joint. The examiner then created the 100-degree angle with a goniometer. After a pause of two seconds, the elbow was returned to its original position, and the participant was asked to reproduce the angle, pause for two seconds, and return to the original position, repeating this maneuver two more times. In each of these steps, a photograph of the angle reproduced by the participant was taken by the camera. The AJPS of the shoulder was measured in the supine position, and the markers were placed on the tip of the ulna and olecranon bones and on both sides of the hands on the bed. The initial position was at 90 degrees angle for the shoulder and elbow; 50 degrees was applied for internal rotation of the shoulder and 30 degrees for its external rotation. The initial angle was measured with a goniometer, and then the participant performed the rotation with their eyes closed, and a photograph of the angle was taken in each repetition. All these steps were done again 2 hours later and 2 days later. Figures 1 and 2 show the active reproduction of the angles for the shoulder and elbow. At the end of the three phases of evaluation, we imported the relevant photos into the AutoCAD program and obtained the angles by creating line segments from the marker places and connecting them. To obtain the angle reproduction error, the values of absolute error (i.e., the difference between the produced angle and the initial angle without considering the direction of motion) and relative error (i.e., the difference between the produced angle and the initial angle with considering the direction of motion) were calculated. These values for each joint were entered into SPSS v. 19 software. The within-group comparison was performed between the results of the first and second phases to assess intra-day reliability of the test, and a between-group comparison was carried out between the results of the first and third phases to evaluate its inter-day reliability. We used ICC, 95% test power, a significance level of 0.05, and SEM to evaluate absolute repeatability between measurements.

**Results**

The characteristics of height, weight, and Body Mass Index (BMI) of the participants are presented in Table 1. The

| Characteristics      | Mean±SD       | Median       |
|----------------------|---------------|--------------|
| Age (y)              | 29.1±4.79     | 21-37        |
| Weight (kg)          | 76.3±12.57    | 60-86        |
| Height (cm)          | 173.7±11.52   | 158-190      |
| Body mass index (kg/m²) | 25.52±2.88   | 30.86-21.8   |
mean and standard deviation of absolute and relative errors obtained from the three measurements are shown in Table 2. All P values were ≤0.005. According to Shrout’s ICC classification [26], ICC <0.40 indicates poor reliability, 0.40-0.75 indicates moderate reliability, and ICC >0.75 shows excellent reliability. The high ICC for absolute and relative errors in internal and external shoulder rotations and elbow flexion measured in one day indicated that the image capture technique had excellent inter-day reliability to assess AJPS. The high values of ICC for all measurements in several days also indicated the excellent intra-day reliability of this technique. SEM value was also greater than the mean difference in all measurements, indicating absolute repeatability between measurements. Table 3 shows the ICC and SEM values for the measurements.

### Table 2. Mean and Standard Deviation (SD) of relative and absolute errors in 3 measurements

| Type of Movement            | Mean±SD The First Measurement | Mean±SD The Second Measurement | Mean±SD The Third Measurement |
|-----------------------------|-------------------------------|--------------------------------|-------------------------------|
| Relative error (degree)     |                               |                                |                               |
| Shoulder external rotation  | 1.33±3.24                     | 0.56±4.39                      | 1.36±3.06                     |
| Shoulder internal rotation  | -7.2±2.98                     | -7.36±3.0                      | -6.63±3.25                    |
| Elbow flexion               | -5.73±2.01                    | -6.4±1.85                      | -5.8±1.84                     |
| Absolute error (degree)     |                               |                                |                               |
| Shoulder external rotation  | 2.03±1.59                     | 3.63±2.54                      | 3.30±1.52                     |
| Shoulder internal rotation  | 7.26±2.81                     | 7.56±2.50                      | 6.90±2.68                     |
| Elbow flexion               | 5.80±1.86                     | 6.40±1.85                      | 5.8±1.84                      |

Discussion and Conclusion

Excellent ICC for relative error (0.9) and absolute error (0.8) of all movements and three measurements indicated high reliability of the joint image capture technique. Olayi, in a similar study, used the image capture technique by digital camera for the shoulder joint at angles of 30, 45, 65, and 70 degrees while the goniometer was attached to the joint. The obtained results of absolute and relative error of each angle (0.97) showed excellent inter-day reliability of the technique [23]. One of the limitations of their study was its small sample size, which limits the possibility of generalizing the results. Irving et al. compared the reliability of measuring the sense of knee joint position with a goniometer and image capture technique, measured by two examiners in standing position at angles of 20, 40, 75, and 100 degrees. IPad2 was used for taking images, and only one image was taken from each angle, and the participants returned for a second measurement a week later. Their results

### Table 3. ICC and SEM values of inter-day and intra-day reliability

| Type of Movement            | Inter-day Reliability | Intra-Day Reliability |
|-----------------------------|-----------------------|-----------------------|
|                            | Intraclass Correlation Coefficient | Standard Error of Measurement | ICC | SEM |
| Relative error              |                        |                        |     |     |
| Shoulder external rotation  | 0.98                   | 0.71                  | 0.94 | 1.73 |
| Shoulder internal rotation  | 0.96                   | 1.21                  | 0.98 | 0.79 |
| Elbow flexion               | 0.96                   | 0.71                  | 0.90 | 1.16 |
| Absolute error              |                        |                        |     |     |
| Shoulder external rotation  | 0.92                   | 0.84                  | 0.8  | 1.70 |
| Shoulder internal rotation  | 0.93                   | 1.35                  | 0.97 | 0.86 |
| Elbow flexion               | 0.96                   | 0.68                  | 0.90 | 1.11 |
for the goniometer and image capture technique showed poor to moderate reliability [27]. This result can be related to the long period between two measurements and taking only one picture from an angle [28]. In another study by Relph, the reliability (ICC) of the image capture technique for the knee joint in the sitting and prone positions was reported to be 0.96 by one tester and 0.98 by several testers [21]. For the goniometer, a study reported poor to moderate reliability for measuring the wrist joint position sense at 20 and 45 degrees of extension and flexion, where at 20° flexion angle, it was more reliable [15]. In Dover et al.’s study, an inclinometer was used to measure the AJPS, and a dynamometer was used to measure shoulder force reproduction. They reported very high reliability (0.99). However, they only calculated absolute error [29], while it is better to use relative error because relative error also determines the direction of movement. The inclinometer, like other methods used in studies, has a less clinical aspect.

Few review studies have been performed to find the best measure of the sense of shoulder joint position, which has validated the passive test for the shoulder in the 90-degree abduction and internal rotation [24]. The isokinetic dynamometer has also been suggested as an efficient method for assessing the sense of joint position. Despite low reliability, it allows the evaluation of the cerebral hemispheres in terms of sensorimotor abilities [30]. However, it is not possible to use these facilities in all medical centers. In a study by Juul-Kristensen, the AJPS of the elbow was measured by an electrogoniometer, and the passive joint position sense was measured by the device. The results showed moderate reliability (0.59 and 0.69) for absolute error and poor reliability for variable error of AJPS measured by electrogoniometer [31].

The image capture technique has reliability for measuring the AJPS of the shoulder and elbow. The simplicity and availability of this measurement method make it possible to use it extensively in medical centers and especially in the rehabilitation treatment process to evaluate joint proprioception.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed about the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be available to them. Also, this study was approved by the ethics committee of the University of Social Welfare and Rehabilitation Sciences.

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Authors’ contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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مقاله پژوهشی:
تکرارپذیری اندام پزشکی حس وضعيت مفصلی با استفاده از تکنیک عکس برداری در اندام فوقانی

افرا سالم
ایرج علی اللهی
گروه فیزیوتراپی، دانشگاه علوم توانبخشی و سلامت اجتماعی، تهران، ایران.

حس عمقی، درک آگاهانه از وضعیت اندام در فضا را فراهم می‌کند که باعث آگاهی از وضعیت قرار گیری و میزان حرکت مفاصل، هدف از دست آوردن تعادل و فشار مفاصل می‌شود. حس عمقی علاوه بر حس حرکت و محل قرارگیری مفصل، در کنترل حرکت به ویژه در برنامه‌ریزی حرکت و مکانیسم‌های فیکسیون مفصلی نقش مهمی دارد و به منظور اطمینان از صحیح‌گیری این امر، روش‌های مختلفی می‌تواند برای اندازه‌گیری حس عمقی به کار رسانده شود. تکنیک‌ها و ابزارهای اندازه‌گیری مختلفی به منظور اندازه‌گیری اجزای مختلف حس عمقی مورد استفاده قرار گرفته‌اند که معمولاً پرهزینه و غیربالینی هستند. تکنیک عکس برداری از مفاصل که روشی آسان و کاربردی به منظور بررسی حس وضعیت مفصلی گهواره با در نظر گرفتن تمامی متغیرهای اثرگذار بر حس وضعیت استفاده شده‌است و نتایج را در انتهای تکرار پذیری تکنیک عکس برداری در مفاصل زانو با تکرار در روزهای مختلف و سه روزهای بعد از انجام تکرار شده است. نتایج حاصل در تکرار پذیری نسبی برای اندازه‌گیری هر حرکت و از دست آوردن خطای بازسازی زاویه، بالای 0/92% و بالاتر در اکثر حرکات آرنج و شانه در اندازه‌گیری تکرارپذیری و 0/80% در خطای مطلق، با تکرارپذیری در روزهای مختلف، به عنوان یک روش قابل اعتماد برای اندازه‌گیری حس وضعيت اندام فوقانی در مرکز‌های درمانی مورد استفاده قرار گرفته است.

کلیدواژه‌ها:
حس عمقی، تکرارپذیری، خطای بازسازی زاویه، اندازه‌گیری تکنیک عکس برداری مفاصل
سال ۲۰۰۰ میلادی مطرح شد که که ابتدا تکنیک‌های کاربردی و در درست‌ساز درمانگران است و بر خلاف سایر روشهای نامبینه نیاز به ایمانه پیش‌بینی ندارند و محروم به استفاده از آزمایشگاه‌های مثبت [۱۶] استفاده نشده است. تکنیک عکس برداری به بررسی نواحی مفصلی در زاویه و برداشت و تکرار‌پذیری خوبی برای تکنیک عکس برداری گزارش کرده است [۱۷]. در حالی که این تکنیک عکس برداری در دستگاه‌های طبقه بالا می‌باشد. اگر یک روش قابل قبول برای تکرار‌پذیری خوبی برای تکنیک عکس برداری گزارش گردید، این روش برای درمانگران قابل استفاده در زمون‌های مختلف خاصی است. خوبی برای درمانگران قابل استفاده در زمون‌های مختلف خاصی است. خوبی برای درمانگران قابل استفاده در زمون‌های مختلف خاصی است. خوبی برای درمانگران قابل استفاده در زمون‌های مختلف خاصی است.
از جمله، چشم عابر توسط کارکنان انجام می‌شد و در هر تکرار زاویه وارد کرده و زاویا با ایجاد پاره‌خط‌هایی از محل نشان‌گرهای اتصال زاویه ایجاد شده با زاویه اولیه بدون نظر گرفتن جهت حرکت است. و خاطر نسبی که کارکنان با زاویه اولیه بدون نظر گرفتن جهت حرکت ایجاد می‌شود، یک عکس از زاویه ساخته شده گرفته می‌شود. تمام این مراحل یک ساعت بعد و در زمان بعد از انجام شدند.

**صافره 2 و 3**

با رساندن عکس بین شانه و آرنج را زده شد. افراد در دو جلسه آزمون مشابه که با فاصله دو روز انجام می‌گرفتند، حضور یافتند و در هر جلسه حس وضعیت فیزیولوژیک عکس‌برداری انجام گرفت. نتایج آن‌ها با مداخله شرکت‌کننده می‌شد تا اگر از محترمی برگردید به‌دست آمده در کتاب‌خوانی که در پایان قرار داشت، ترتیب اندازه‌گیری مقادیر شانه و آرنج را تعیین کند. در تصویر شماره 1 مراحل انجام مطالعه به‌اختصار نشان داده شده است.

برای اندازه‌گیری حس وضعیت مفصل ابتدا لندریکه‌های مربوطه را در برنامه اتوکد وارد کرده و روی آن‌ها با ایجاد پاره‌خط‌هایی از محل نشان‌گرهای اتصال به یکدیگر به دست آمده، باید به دست آوردن خطای اضطرابی از مقادیر خطای مطلوب که اختلاف زاویه ایجادشده با زاویه اولیه بدون نظر گرفتن جهت حرکت است، و خطای نسبی که اختلاف زاویه ایجادشده با زاویه اولیه با نظر گرفتن جهت حرکت است، ضرر محاسبه شده شد. این مقادیر را برای هر مفصل در نرم‌افزار SPSS به‌کمک نسخه 19 وارد کردیم. به‌طوری‌که برای یک نفر SPSS اول و دوم به منظور اندازه‌گیری تکراری‌های روز و بین روز، و سوم به منظور اندازه‌گیری تکراری‌های در روز انجام شدند. از منظورهای از آماری ICC آماری برای ارزیابی تکراری‌های مطلوب استفاده شد.

**صافره 4**

پایان‌های و یزگ‌های قد، وزن و شاخص توده بدنی شرکت‌کننده‌اند. در چند کلمه شماره 1 آورده شده است.

همچنین میانگین و انحراف معیار خطای مطلوب و نسبی بعدست‌آمده در سه بار اندازه‌گیری در چند شماره 2 آمده است.

در مطالعه حاضر تمامی مقادیر P<0.005 است. بهتر شرود (2014) Shroud ICC تقویم‌بندی شده در زیر (40/40) و عایلی در نظر گرفته می‌شود [2]، انتخاب میزان الی‌ای ICC خطای مطلوب و نسبی، برای حرکت اصلی شانه

**صافره 5**

به منظور اندازه‌گیری حس وضعیت مفصل شانه، فرد طی قرار گرفتن روی صندلی، و نشان‌گرهایی در محل سر استخوان اولنا، اوپر کارون و دو طرف دست به‌طور متقابل می‌گرفتند.
داخلي و خارجي شانه و فلکشن آرنج در یک روز نشان می‌دهد که استفاده از تکنیک عکس‌برداری برای ارزیابی حس وضعیت مفصلی فعال از تکرارپذیری برای اندازه‌گیری در روز برخوردار است. همچنین میزان بالای ICC برای تمام حرکات در جنگ روز نشان دهنده تکرارپذیری عالی این تکنیک برای اندازه‌گیری بنین روز است.

نیز در تمام موارد از اختلاف میانگین ها بیشتر است که SEM نشان دهنده تکرارپذیری مطلق در بین تست‌های SEM برخوردار بود.

پیشنهاد میزان عالی ICC برای اندازه‌گیری بالای تکرارپذیری عکس‌برداری است. استفاده از تکنیک عکس‌برداری ضعیف تا متوسط بود [33] که می‌توان آن را به فاصله طولانی مدت بین اندازه‌گیری و فقط یکبار عکس‌برداری از راهه مرتب داشت [32] در حالی که در مطالعه ICC باعث می‌گردد که میزان 4 تا 5 از اختلاف این ارتباط باعث تکرارپذیری می‌شود که میزان تکرارپذیری یک تصویر در چرخش خارجی شانه توسط شرکت‌کنندگان بر روی این مطالعه مشابهی که توسط ایرینگ [21] انجام شد با تکنیک عکس‌برداری توسط دوربین دیجیتال پری برای مفصل شانه در بررسی خطای مطلق و نسبی هریک از زاویه‌ها در جنگ روز. شاخص خریداری شده همچنین این روش از پایان به پایان برخوردار بود [22].

یک عکس گرفته شده در مطالعه مشابهی که توسط ایرینگ [25] انجام شد با تکنیک عکس‌برداری توسط دوربین دیجیتال برای مفصل شانه در بررسی درجه ۷۰ و ۶۵، ۴۵، ۳۰، ۲۰ و ۱۰ درجه مطلایی که توسط دیگری که توسط رلف انجام شد، تکرارپذیری تکنیک عکس‌برداری برای مفصل زانو در وضعیت نشسته و دمر برای اندازه‌گیری در روز با تکرارپذیری می‌گردد.

جدول ۱. وزنی های ایجاد شده در شرکت‌کنندگان در مطالعه حاضر

| متغیر | میانگین ± انحراف معیار | میزان BMI |
|-------|------------------------|-----------|
| سن (سال) | ۲۹/۱±۴/۷۹ | ۲۵/۵۲±۲/۸۸ |
| وزن (کیلوگرم) | ۷۶/۳±۱۲/۵۷ | ۲۱/۸-۳۰/۸ |
| قد (سانتی‌متر) | ۱۷۳/۷±۱۱/۵۲ | ۱۵۸-۱۹۰ |
| BMI | ۲۷/۲۳ | ۲۸/۲۳-۲۵/۸ |

ارجع مطالعی و اقدام کیفی دهی تکرارپذیری اندازه‌گیری حس و وضعیت مفصلی با استفاده از تکنیک عکس‌برداری در اندام فوقانی افراد سالم

ویژگی‌های جمعیت شرکت‌کنندگان در مطالعه حاضر.
تاکنون مطالعات مروری اندکی به منظوری استفاده از تکنیک‌های دیگری که برای حس وضعیت مفصلی استفاده می‌شود و در دسترس بر این حس وضعیت مفصلی می‌باشد. در اینمیل‌سنجی‌ها، گونیامتر استفاده شده است که تکرارپذیری ضعیف و متوسطی را برای حس وضعیت مفصلی در درجه‌های اکستنشن و فلکشن گزارش کرده است. 45 درجه فلکشین درجه‌ای قابل اعتمادتر است. در مطالعه‌های داور، قوزن‌گیری از اینکلاینومتر به منظور اندازه‌گیری حس وضعیت فعالی و از دینامومتر به منظور اندازه‌گیری بازتولید نیروی شانه استفاده شده است. در این مطالعه، میانگین و انحراف معیار خطاهای مطلوب استفاده شده است. در مطالعه‌های غیرفعال، الکتروگونیامتر و حس آستانه حرکت پسیو توسط دستگاه‌های مناسب گزارش شده و نتایج میانگین و انحراف معیار خطاهای مطلوب استفاده شده است. در مطالعه‌های غیرفعال، الکتروگونیامتر و حس آستانه حرکت پسیو توسط دستگاه‌های مناسب گزارش شده و نتایج میانگین و انحراف معیار خطاهای مطلوب استفاده شده است.

جدول 3. شرایط SEM و ICC تکرارپذیری بین روز و تکرارپذیری ۲ روز

| نوع حرکت | تکرارپذیری بین روز | تکرارپذیری ۲ روز |
|----------|-------------------|-------------------|
| SEM      | ICC               | SEM              | ICC              |
| ۱۸۷۳     | ۱۸۸۱              | ۱۸۸۸             | ۱۸۶۸             |
| ۱۸۸۰     | ۱۸۸۱              | ۱۸۳۷             | ۱۸۳۶             |
| ۱۸۷۵     | ۱۸۸۱              | ۱۸۳۷             | ۱۸۳۶             |
| ۱۸۷۳     | ۱۸۸۱              | ۱۸۳۷             | ۱۸۳۶             |

11. Dover
نتایج گزارشی
نتایج به دست آمده از مطالعه حاضر نشان دهنده ارزیابی حس وضعیت مفاصل شانه و آرنج با تکنیک عکس برداری از تکرارپذیری بالایی برخوردار است. سادگی و دردسترس بودن این روش اندازه‌گیری، امکان استفاده‌گسترده در مراکز درمانی و بطوریکه در روند درمان نورپردازی به مانند ارزیابی حس عمقی را قرار می‌دهد. یکی از محدودیت‌های این مطالعه حجم نمونه‌اند. است که امکان بست‌نجاتی را محدود می‌کند.

ملاحظات اخلاقی
پیروی از اصول اخلاق پژوهش
اصول اخلاقی تمام‌اً در این مقاله رعایت شده است. شرکت‌کنندگان اجازه داشتند در زمانی که مایل بودند به زودی خارج شوند. همچنین همه شرکت‌کنندگان در جریان برنامه درست کردند. اطلاعات آنها محرمانه نگهداری شد. همچنین این مقاله مورد ماکیتی کمیته‌ای اخلاق درمان، پژوهش و سلامت اجتماعی قرار گرفت.

حامي مالي
این تحقیق هیچ گونه کمک مالی از سازمان‌های تأمین مالی در بخش‌های عمومی، تجاری یا غیرانتفاعی دریافت نکرد.

مشارکت نویسندگان
تمام نویسندگان در طراحی، اجرا و نگارش همه بخش‌های پژوهشی حاضر مشارکت داشتند.

تعارض منافع
بنابر اظهار نویسندگان این مقاله تعارض منافعی ندارد.

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