Open Journal of Health Science & Medicine

OJHSM

Research Article

OJHSM-2-106

Validating the Mobil-Aider to measure Joint Accessory Motion in Healthy Adult Shoulders

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Received date: September 03, 2021; **Accepted date:** September 28, 2021; **Published date:** October 07, 2021

Citation: Tuzson A, Tarleton G (2021) Validating the Mobil-Aider to measure Joint Accessory Motion in Healthy Adult Shoulders. Open J Health Sci Med 2(1): 106.

Abstract

Purpose: The purpose of this project was to validate, *in vivo*, a device designed to measure joint accessory motion magnitude by comparing Mobil-Aider device measurements with measurements obtained from an Ascension electromagnetic motion analysis system.

Subjects: 20 healthy adults: 16 female and 4 male (27.5 yo ± 7.1)

Materials/Methods: The Mobil-Aider device was developed to provide an accurate measurement of joint accessory motion. Two Ascension markers were placed on each arm of the Mobil-Aider device and two additional markers were placed over the left clavicle and the left humerus of each participant. The markers placed over the clavicle and the humerus approximated the measurement of the humerus relative to the clavicle during the posterior glide glenohumeral joint mobilizations. One orthopedic clinical specialist performed 10 posterior glides (grade IV) of the left humeral head in 20 healthy adults. The magnitude of joint accessory motion was measured simultaneously by the Mobil-Aider device and the Ascension electromagnetic system markers.

Results: The Mobil-Aider device measures correlated closely with the measurements obtained from the Ascension markers mounted on the arms of the Mobil Aider device (r = 0.83). On average, the electromagnetic system measured Mobil-Aider device movement of 18 mm (± 3 mm). The Mobil-Aider demonstrated an average movement distance of 10.5 mm (± 2.3 mm) and the clavicle-humerus markers demonstrated an average movement distance of 5.3 mm (± 3.5 mm).

Conclusions: The values obtained using the electromagnetic motion analysis system and the Mobil- Aider device showed close agreement in measuring posterior humeral glide motion of healthy adult shoulders. Radiographic imaging or invasive measures might provide a more accurate measurement of the magnitude of joint mobilization movement, but those methods bring an increased risk to the research participants.

Clinical relevance: Given the challenge of precisely measuring joint mobilization magnitude in the clinic, the Mobil-Aider provides an accurate, practical non-invasive measure of humeral head accessory motion in healthy adult human shoulders.

Key Words: Joint mobilization; Manual therapy; Physiotherapy

Introduction

The APTA Guide to Physical Therapist Practice defines a joint mobilization technique as “a manual therapy technique comprised of a continuum of skilled passive movements that are applied at varying speeds and amplitudes, including a high amplitude/high velocity therapeutic movement” [1]. In an APTA consensus conference in August 2004, joint manipulation and mobilization were included in the minimum skill set required by entry level physical therapists [2].

Joint mobilization techniques have been shown to be a useful adjunct to exercise in the treatment of shoulder dysfunction [3-6]. Eliason, Harringe, Engstrom and Werner compared the effectiveness of a graded exercise program with and without joint mobilization to a control in the treatment of subacromial pain syndrome [3]. The authors found that at six and 12 weeks, the addition of joint mobilization treatments decreased pain during active range of motion compared to the exercise alone group and the control group [3]. A systematic review by Innocenti et al. found that manual therapy was more effective than placebo alone in reducing pain and increasing range of motion in shoulder impingement syndrome [5]. Although these articles support the effectiveness of manual therapy, several articles examining the effectiveness of manual therapy concluded the evidence to be inconclusive or weak [5,7,8]. Research investigating the effectiveness of joint mobilization techniques has been hampered by a lack of consensus of the appropriate amount of force and joint movement delivered during manual therapy. The lack of conclusive evidence to support manual techniques may stem, in part, from the great variability and heterogeneity in manual therapy treatment seen when comparing technique between clinicians.

Although joint mobilization techniques have been shown to have good intra rater reliability when performed by an experienced therapist [9], the inter-rater reliability between multiple therapists has been shown to be only fair or moderate with a kappa ranging from 0.28 to 0.43 [10]. When Chiradejnant et al. examined the forces exerted by ten different therapists during manual therapy of the lumbar spine, the standard deviations for each of grades I through IV ranged from 24% to 50% of the total force exerted with grade I showing the greatest variability between providers [11].

Perhaps because of these reliability issues, the research reports examining manual therapy have not ‘improved over time’ according to Alverez at al. [12]. Similarly, Karas and Plankis [13] called for improved methodology to assess the reliability and validity of manual therapy in 2016. However, considering the large variability observed between practitioners, systematically studying the effectiveness of manual therapy proves difficult. To demonstrate the effectiveness of manual therapy techniques, therapists must first improve the consistency with which joint mobilizations are delivered. Once a standardized method is determined, and consistent delivery methods are documented, then the efficacy of that standardized treatment method can be determined.

To fill this need and help standardize joint mobilization techniques across practitioners, the Mobil-Aider was developed to provide a convenient and easy way to measure the movement distance of two joint surfaces during joint mobilization techniques [14]. The Mobil-Aider was designed with interchangeable parts to allow measurement of passive accessory motion of common joints (shoulder, elbow, wrist, knee, and ankle). The purpose of this current project was to validate the Mobil-Aider ‘*in vivo*’ by comparing the measurements read on the Mobil Aider screen with measurements obtained from an Ascension electromagnetic motion analysis system during grade IV shoulder joint mobilizations on healthy adult shoulders. The validity of the Mobil-Aider has been established using radiographs and Zeiss microscopes [14,15], but validity has not been determined while performing multiple joint accessory movements as performed in a clinical setting using the Mobil-Aider device on human participants. In addition to measuring the movement of the Mobil-Aider device, Ascension system markers were placed on the humerus to measure movement of the humerus during the joint mobilization techniques.

Methods

Sixteen healthy women and four healthy men (average age 27.1 years ± 7.1 years) were recruited for this research. Participants were screened during the consent process to ensure they had no history of shoulder injuries. During data collection, the participants lay supine on a mat table and posterior glide mobilizations were performed to the left glenohumeral joint (Figure A). Ascension electromagnetic markers were placed on both arms of the Mobil-Aider (Figure B) and on the skin over the humerus. One orthopedic clinical specialist with more than 20 years of experienced performed two sets of five grade IV posterior glide joint mobilizations to the left glenohumeral joint of each participant. During the joint accessory movements, a researcher documented the measures reported on the Mobil-Aider screen for each of the 10 posterior glide movements. Simultaneously, the Ascension electromagnetic Trakstar motion analysis system recorded the position of the two markers positioned on the Mobil-Aider device at 248 Hz (Figure C).

Figure A: Experimental set up

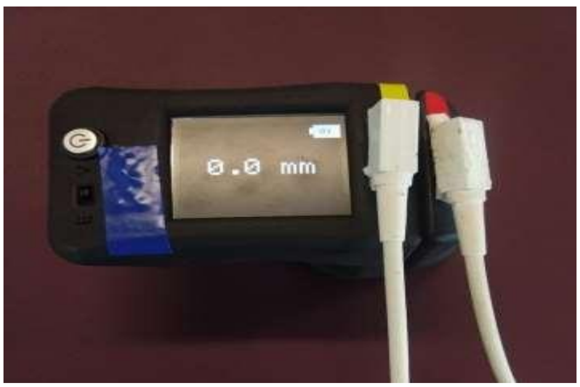

Figure B: The Mobil-Aider with Trakstar electromagnetic markers attached

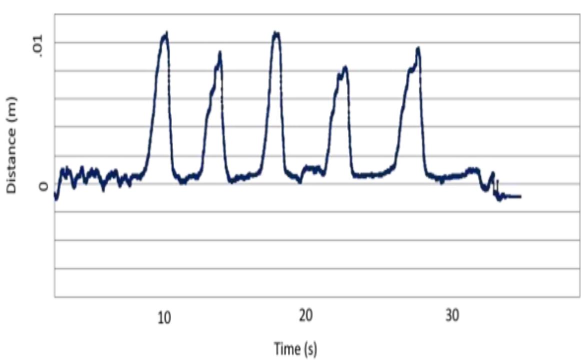

Figure C: Ascension electromagnetic motion capture raw data of joint accessory motion during 1 trial

During data collection, the researcher responsible for data analysis of the Ascension data was blinded to the Mobil-Aider measurements to maintain objectivity. After calculations using the Ascension measures were complete, the Ascension marker measures, and the Mobil-Aider measures were compared using SPSS.

For the Ascension markers, the distance was calculated by comparing the absolute position of the two markers and determining the distance between the two markers at the peak and trough of the accessory motion. The distance between the two markers was calculated at the beginning of each posterior glide motion and at the maximum distance of the posterior glide motion (Figure D).

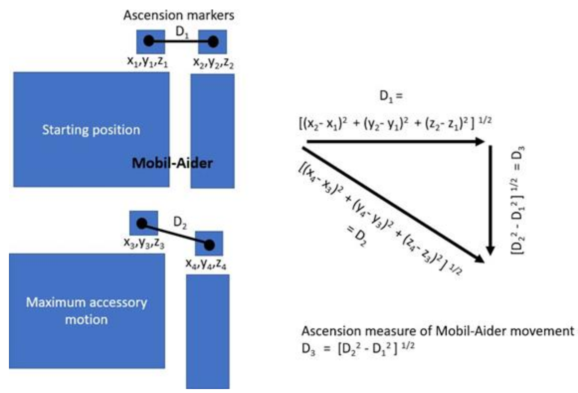

Figure D: Calculation of maximum Mobil-Aider distance using absolute position of 2 Ascension markers in the x, y and z coordinate planes

Then the total movement of marker #2 (Figure B) was determined using the Pythagorean Theorem. This method of calculating relative distance was used because during the joint mobilization technique, both arms of the Mobil-Aider can move on the patient. But the measure of interest is the distance of one arm relative to the second arm. Hence one marker was used to track the position of the 'stationary' arm on the Mobil-Aider and another marker was used to track the position of the 'mobile' arm. By comparing the position of both markers at the peak and trough of the movement we were able to eliminate the unwanted movement when both arms of the device moved on the patient. To measure the movement of the humerus bone, instead of a comparison, the movement of only the one marker was analyzed. To measure humeral movement, the peak or maximum distance moved was subtracted from the initial position before each posterior glide mobilization was performed.

Results

The Mobil-Aider device measures correlated closely with the measurements obtained from the Ascension markers mounted on the arms of the Mobil-Aider device (r=0.83; Figure E). There was no correlation between the Mobil-Aider values and the measures from the markers on the humerus. On average, the Ascension system measured Mobil-

Aider device movement of 18 mm (± 3 mm). The Mobil-Aider demonstrated an average movement distance of 10.5 mm (± 2.3 mm) and the humerus marker demonstrated an average movement distance of 5.3 mm (± 3.5 mm).

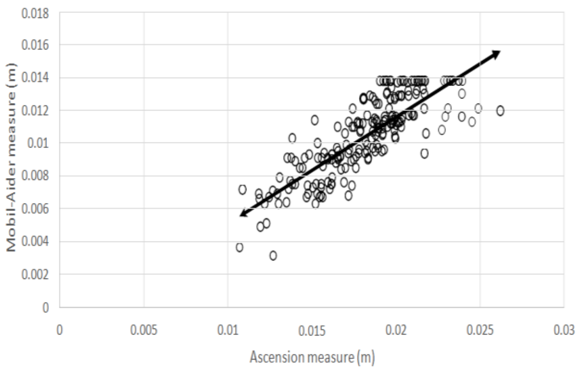

Figure E: Relationship between joint accessory movement measurements obtained by the Ascension system (x axis) and the Mobil-Aider (y axis)

Conclusion

The values obtained using the electromagnetic motion analysis system and the Mobil-Aider device showed close agreement in measuring posterior humeral glide motion of healthy adult shoulders. However, the total movement of the humerus as measured by the ascension marker did not correlate to either measure of joint accessory motion. The challenges of measuring accessory motion of the glenohumeral are numerous. In the seminal article by Inman et al. written in 1944 the authors obtained accurate measures of joint arthrokinematics of the glenohumeral joint by surgically inserting pins into the humerus, scapula and clavicle [16]. These methods were approximated again by McClure et al. in 2001 yielding similar measures of glenohumeral and scapular motion [17]. Using current motion capture systems, measuring the small accessory motion of the humerus and isolating that motion relative to the scapula proved unfeasible in this research.

In other research, joint accessory movement was measured using ultrasound or radiographic methods [18- 20]. But positioning the ultrasound equipment during joint mobilization techniques forces the practitioner to position her hands in an unnatural position during the joint mobilizations [18]. And research measuring joint mobilization distance using ultrasound has failed to provide a comparison 'gold standard' measure for validation [21,22]. A Medline search for 'ultrasound' and "joint movement' and 'validity' revealed one study by Oldfield measuring ulnar radial translation during gripping, pronation and supination [23]. On ultrasound, significant differences were found in ulnar radial translation when comparing gripping, pronation and supination. Although this research may grossly validate the use of ultrasound for measuring joint distances, the authors did not measure joint distances in real time during passive accessory motion. In 2005, Borsa et al. used ultrasound to measure joint accessory motion in swimmers and compared those measurements to non-swimmers. However, the authors failed to find any difference between the shoulder accessory motions of swimmers compared to non-swimmers, furthermore, they found no difference in the accessory motion of painful shoulders vs. non painful shoulders [24]. Only one other study has demonstrated ultrasound as a valid measure of joint accessory motion but similar to Oldfield et al. the methods measured a static position where the humerus was distracted inferiorly [25]. Whether ultrasound is an accurate measure of joint mobilization amplitude, has not yet been proven definitively.

With no clear standardization of joint mobilization technique and no gold standard to measure joint accessory motion, it is no wonder that manual therapy has minimal weak evidence to support its effectiveness. By providing an affordable, easily administered way to measure joint accessory motion, the Mobil-Aider shows promise to improve application and reimbursement of manual techniques.

The measure obtained by the Ascension markers was on average 7.5 mm larger than the measurements provided by the Mobil Aider device. But the two measures (Mobil-Aider and Ascension) showed strong correlation. This implies that this difference is a systematic difference between the two measures. The Ascension measure was calculated using the absolute position of two Ascension markers. Ascension reports an accuracy of their electromagnetic system of 1.4 mm RMS. With the calculations performed (Figure D), this error might have been exaggerated in a systematic manner and might account for the difference in the two measures. The accuracy of the Mobil-Aider is reported as 2% [14]. If the Ascension system tends to exaggerate the distance by 1.4 mm and the Mobil-Aider under measures the distance by approximately 2% [14], this might account for 2 - 3 mm of difference between the measures. Most likely, the additional error comes from interference with the electromagnetic field used to track the Ascension markers and then a multiplication in that error in the calculations performed.

Although the values did not match exactly between the Mobil-Aider and the Ascension Trakstar electromagnetic motion capture system, the correlation between the two measures was strong (r=0.83). This research demonstrated the validity of the Mobil-Aider to measure joint accessory motion during manual therapy of the glenohumeral joint. Although prior research has demonstrated more accurate ways to measure joint accessory motion [18.20], those methods may interfere with the clinician's ability to deliver the manual therapy. Both maintaining the integrity of the clinical technique and the integrity of measurement method are of equal importance to demonstrate the validity of manual therapy techniques in the clinic. The Mobil-Aider provides a cost-effective way to measure the amplitude of joint accessory motion in clinical settings. Manual therapy techniques must be standardized to demonstrate the effectiveness and reliability of joint mobilization treatments. By using the Mobil-Aider, clinicians and researchers can ensure that across practitioners, similar treatments are being performed. By documenting, objectifying, and standardizing manual therapy treatment techniques, clinicians can better demonstrate how manual therapy techniques decrease pain and improve patients' quality of life.

Conflict of Interest

The authors declare there were no conflicts of interest in performing neither this research nor the development of this manuscript.

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