Precision and Validity of a Clinical Method for Pectoral Minor Length Assessment in Overhead-Throwing Athletes

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Precision and Validity of a Clinical Method for Pectoral Minor Length Assessment in Overhead-Throwing Athletes

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ABSTRACT

Methods of assessing pectoral minor length are needed to determine the criterion validity, reliability, and precision of a clinical method for pectoralis minor length assessment. Twenty-nine overhead-throwing athletes volunteered for this study. All measures were taken with an electromagnetic motion analysis system and Palpation Meter. Pearson correlation coefficients were calculated for the average pectoralis minor length values from the electromagnetic motion analysis system and Palpation Meter ($\alpha \leq 0.05$) to determine the validity of pectoralis minor length. Intraclass correlation coefficients ($ICC_{2,k}$) and standard error measures were calculated to determine the intrarater reliability and precision of pectoralis minor length measures. Significant correlations were found between pectoralis minor length measures from the electromagnetic motion analysis system and Palpation Meter for the dominant and nondominant arms. The Palpation Meter was also found to be reliable and precise when measuring pectoralis minor length for the dominant and nondominant arms.

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The overhead-throwing motion is one of the most dynamic movements performed in sports today.[1] Due to this incredible movement, overhead-throwing athletes regularly sustain shoulder injuries.[2,3] The resting position of the scapula is believed to be an important indicator of shoulder injury risk.[4-7] Repeated overhead-throwing motions are believed to cause extreme stress[1,8-10] on both the active and passive structures of the shoulder and contribute to soft tissue adaptations that facilitate altered scapula positioning.[6,11-15] Specifically, overhead-throwing athletes are described to exhibit increased scapula upward and internal rotation, anterior tilting, or protraction on their dominant arm compared with their nondominant arm.[11,16-18] Given the importance of scapula position as a risk factor for shoulder injury, it is important to assess factors that influence scapula positioning.

Pectoralis minor tightness has been implicated in altering scapula position.[19,20] The pectoralis minor originates on the proximal third, fourth, and fifth ribs and inserts on the medial portion of the coracoid process of the scapula. Given the anatomic location of the pectoralis minor, participants with a shortened resting pectoralis minor length demonstrated decreased scapula posterior tipping and increased internal rotation due to the attachment sites approximating during arm elevation.[20] These alterations in resting scapula position are thought to reduce the subacromial space, which may impinge both the supraspinatus and the long head of the biceps tendon, as well as the subacromial bursa.[21-24]

Individuals with shoulder impingement syndrome also demonstrated increased protraction, anterior tilting, and internal rotation.[6,22,25-29] Thus, assessment of pectoralis minor length is integral in the prevention and treatment of shoulder injuries in overhead-throwing

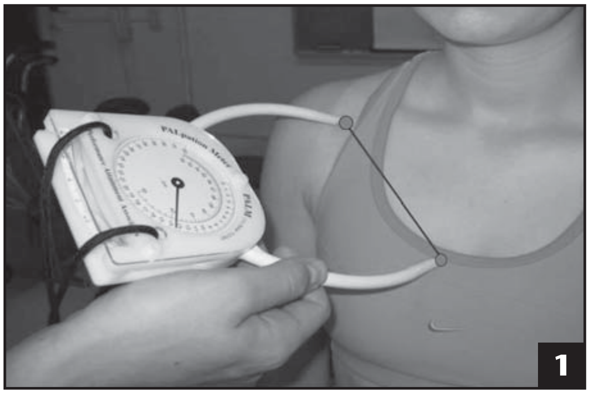

Figure 1. The Palpation Meter (Performance Attainment Associates, St. Paul, Minnesota) placed on the particpant measuring pectoralis minor length.

athletes. Previous research investigating pectoralis minor length used an electromagnetic tracking system, which is valuable to clinicians but highly impractical in the clinical setting due to its cost and complexity of use.[30,31]

A variety of instruments are used to clinically measure pectoralis minor length. Recently, Borstad[32] concluded that the pectoralis minor length may be attained using a skin-based caliber assessment. Another instrument commonly used is the Palpation Meter (PALM) (Performance Attainment Associates, St. Paul, Minnesota) (Figure 1). The PALM combines a caliper and an inclinometer into one tool that measures distance and was shown to be a valid and reliable instrument for assessing postural alignment, including pelvic height and leg length discrepancies and scapular orientation.[33-35] The distance in centimeters is shown using a circumferential ruler with a pointer. The PALM is well-suited to provide measurement of the pectoralis minor length because it is both cost effective and user friendly; however, we are not aware of any literature establishing the validity and reliability of the PALM for measuring pectoralis minor length. Therefore, the purpose of this study was to determine the criterion validity, reliability, and precision of a clinical method for pectoralis minor length assessment using the PALM. Laboratory-based 3-dimensional motion analysis was used as the gold standard against which we assessed the validity of the PALM to measure pectoralis minor length. Intrarater reliability and precision were also assessed across multiple trials during a single test session.

These studies demonstrate that pectoralis minor length measured through laboratory instrumentation is valid and reliable.[30,31] Thus, there is a need to establish a method to clinically measure pectoralis minor length in overhead-throwing athletes that is valid, reliable, and precise.

METHODS

Participants

Twenty-nine (15 male and 14 female) healthy, overhead-throwing athletes participated in this study. All 29 participants were students from the University of North Carolina at Chapel Hill who spent at least 45 minutes per day, 3 times per week, practicing or playing with their dominant humerus above 90° in their respective sport. There were 10 club volleyball players, 3 Division I varsity volleyball players, 4 recreational tennis players, 6 club softball players, and 6 club baseball players. Participants were excluded if they were currently experiencing shoulder pain or had participated in formal shoulder rehabilitation during the past 6 months. Prior to participation, all participants signed an informed consent form approved by the University's institutional review board. Participants then completed a short medical history questionnaire to determine whether they met the study's inclusion criteria.

Pectoralis Minor Length

The PALM (Figure 1) was used to measure pectoralis minor length. The accompanying slide rule PALM calculator was not used in this study. Laboratory measures of pectoralis minor length were taken by the Motion Star electromagnetic motion analysis system (EMAS) (Ascension Technology Corporation, Burlington, Vermont) interfaced with Motion Monitor (Innovative Sports Training, Chicago, Illinois) acquisition software used to assess resting pectoralis minor length at a sampling rate of 50 Hz. The EMAS was used as a criterion to validate the PALM's clinical measurement.

Participants reported to the Sports Medicine Research Laboratory for a one-time testing session that lasted for approximately 75 minutes. Participants wore athletic attire, including a sports bra or tank top so that the shoulder could be appropriately exposed for preparation of measurements to be taken. After signing the informed consent form, the EMAS receivers were placed on select bony landmarks of both upper extremities, which were patterned after landmarks recommended by the International Shoulder Group protocol.[36] The specific hardware used in this investigation consisted of a standard range direct current transmitter and 5 receivers. Participants were instructed to stand in a relaxed position with their wrists in a neutral position (palms facing in), while measuring pectoralis minor length with both the PALM and the EMAS. Three trials of measurements of the dominant and nondominant pectoralis minor length were assessed first by the PALM and then by the EMAS. The order of testing nondominant versus dominant was randomized prior to the trials.

PALM-measured pectoralis minor length was obtained by placing the PALM's caliper tips on the medial coracoid process and the fourth intercostal space adjacent to the sternum on the participant's dominant and nondominant arms (Figure 1).[20,32] According to Borstad,[32] this is the "central vector" for the pectoralis minor. The central vector was measured in centimeters and was defined as the pectoralis minor length for this study. The participant was asked to stand in a relaxed position as 3 consecutive measurements were made with the PALM for each shoulder. The clinician holding the PALM was blinded to the actual pectoralis minor length measures as another trained clinician stood adjacent to the tester, recording the pectoralis minor lengths.

After the 3 trials of the PALM-measured pectoralis minor length were obtained, EMAS receivers were placed on selected bony landmarks using double-sided tape and elastic wrap, which was used to additionally secure the receiver over the posterior humerus. A global reference system was set up using X, Y, and Z axes that corresponded to the 3 cardinal planes of the body. A digitizing stylus connected to a receiver was used to digitize bony landmarks, allowing segment-based local coordinates to be established for the humerus, scapula, and thorax. Receivers were placed on the participants' thorax over the spinous process of C7, on both shoulders over the broad flat surface of the acromion, and on the posterior one-third of the upper arms with the receiver over the area of least muscle mass to minimize potential receiver movement. Bony landmarks were digitized using the International Shoulder Group protocol.[36] After digitization, the participant was instructed again to stand in a relaxed position for three 5-second trials while the EMAS took measures of the pectoralis minor length in the dominant and nondominant shoulder.

Data Reduction

Three-dimensional coordinates of the digitized bony landmarks were calculated using the Motion Monitor software. Segment reference frames were defined according to the recommendations set forth by the Shoulder Group of the International Society of Biomechanics.[36] EMAS-measured pectoralis minor length was operationally defined as the linear distance between the digitized landmarks of the coracoid process and fourth intercostal space near the sternum. The average of 3 trials of the PALM-measured pectoralis minor length was used in this analysis. This was compared with the EMAS-measured pectoralis minor length, which was averaged over the 3 separate trials using a custom Matlab program (Mathworks, Natick, Massachusetts) and used for statistical analyses. The average measurement of the 3 consecutive trials of pectoralis minor length for each shoulder was used for the statistical analyses.

Data Analysis

Bivariate Pearson product moment correlation analysis was used to determine the relationship between the PALM-measured pectoralis minor length (clinical assessment) and EMAS-measured pectoralis minor length (laboratory and gold standard assessment) for both the dominant and nondominant arms. The correlation coefficients were used to determine the criterion validity of PALM-measured pectoralis minor length with an a priori alpha level of 0.05. The intratester reliability and precision of PALM-measured pectoralis minor length were determined by calculating the intraclass correlation coefficient ($ICC_{2,k}$) and standard error of the measurement (SEM) values. Statistical analysis was performed with SPSS software, version 13.00 (SPSS, Inc, Chicago, Illinois).

RESULTS

There were significant correlations between pectoralis minor length measures from the EMAS and PALM for the dominant ($r = 0.695$, $P \leqslant .005$) and nondominant ($r = .837$, $P \leqslant .005$) arms (Figure 2). The PALM was also found to be reliable and precise for the dominant (ICC = .980, SEM = .320 cm) and nondominant (ICC = .990, SEM = .29 cm) arms.

DISCUSSION

The primary purpose of this study was to determine the validity, reliability, and precision of the PALM when

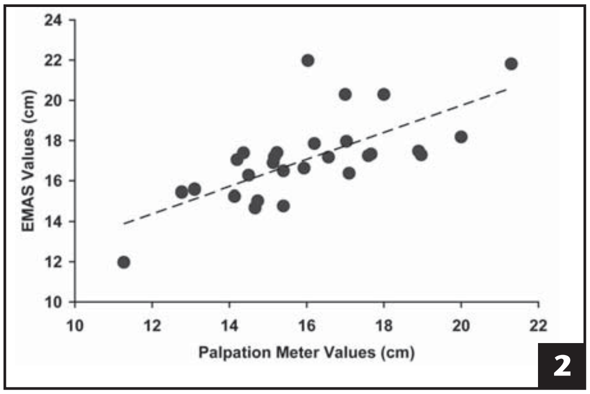

Figure 2. Values of pectoralis minor length (cm) measured using the Palpation Meter (Performance Attainment Associates, St. Paul, Minnesota) and electromagnetic motion analysis system (EMAS) (Ascension Technology Corporation, Burlington, Vermont).

measuring pectoralis minor length. Our results indicate that the PALM is able to accurately measure pectoralis minor length with minimal error when the shoulder is in a resting position in overhead-throwing athletes. Thus, the ability to objectify pectoralis minor length using the PALM in overhead-throwing athletes may allow the clinician to determine faulty posture and gain valuable information to help prevent and reduce shoulder injuries.

There have been few published studies measuring pectoralis minor length directly; however, researchers have attempted to measure pectoralis minor length using forward shoulder posture.[29,37-39] With the participants in a supine position, Host[37] estimated pectoralis minor length by measuring the distance between the posterior acromion and the table. This method attempts to measure scapular protraction and internal rotation otherwise known as forward shoulder posture. The same protocol was used in a similar study with healthy and unhealthy participants.[39] However, the weakness of both these studies was the inability to provide an exact and direct measurement of pectoralis minor length.

Our study attempted to validate the PALM for direct measurement using previously validated skin-based landmarks.[20,32] Borstad and Ludewig[20] and Borstad[32] determined that the inferomedial aspect of the coracoid to the superior border of the fourth intercostal space represented a valid measurement of length of the pectoralis minor muscle ($ICC_{3,1}$ = .96, SEM = .5 cm). Borstad's most recent research indicates very good agreement between the caliper-measured pectoralis minor length and that of the EMAS.[32] One of Borstad's concerns was the generalizability of his findings to other therapists and patient populations; however, the current study further bolsters his conclusion that a skin-based measurement of the pectoralis minor length using a caliper is valid, reliable, and feasible, at least, in the overhead-throwing athlete population.

Establishment of criterion validity occurred through the correlation between the PALM and EMAS measurements. The EMAS measurements were used as our gold standard to compare with the PALM measurements. The EMAS has been used in previous studies that have measured pectoralis minor length, as well as in numerous studies looking at scapula position and movement.[16,17,20,32,40,41] Borstad and Ludewig[20] and Borstad[32] used the EMAS system and cadavers to measure pectoralis minor length. After measuring the pectoralis minor length with the EMAS system, the pectoralis minor was dissected, measured, and determined to be valid means to measure pectoralis minor length.[20,32] In addition, Karduna et al[30] assessed the accuracy of skin-based EMAS devices to measure scapula position by using bone pins placed along the spine of the scapula.[30] With the pins physically placed in the scapula of each participant to track the actual kinematics, the EMAS was again found to be a valid measure of scapular position.[30] Thus, we chose EMAS as a viable tool to be used as the gold standard for assessing scapula position and pectoralis minor length.

There have been a few previous studies that use the PALM device to measure pelvic heights and scapular position.[34] da Costa et al[33] determined the reliability of the PALM-measured scapular orientation and had good to excellent intratester and intertester reliability with SEM values of less than .8 cm. In addition, Petrone et al[34] measured pelvic height differences in 15 healthy and 15 symptomatic active military personnel using the PALM and radiograph. The PALM was determined to be valid ($ICC_{2,3}$ = .90 for rater 1 and .92 for rater 2) with excellent intertester reliability ($ICC_{3,3}$ = .97 and .98) and good intratester reliability ($ICC_{2,3}$ = .88).[34] A similar study used the PALM to determine leg length differences in participants with or without lateral patella femoral syndrome.[35] Although the study by Petrone et al[34] successfully used the PALM to measure hip height, Carlson and Wilkerson[35] described possible errors when placing the PALM's points on the ASIS landmarks on participants with higher amounts of subcutaneous fat.

There were similar limitations to our study. For example, differences in the reliability of the PALM measured pectoralis minor length in the dominant arm compared with the nondominant arm indicate the need for further research using the PALM. Although both of the *r* values were relatively high (dominant, $r = .695$, $P \leqslant .005$; nondominant, $r = .837$, $P \leqslant .005$), the dominant arm measurements had a weaker correlation with the EMAS. This may be explained by the increased muscularity of the dominant arm of overhead-throwing athletes and the difficulty of palpating the coracoid process and fourth intercostal space. In addition, only healthy, college-aged overhead-throwing athletes were tested; thus, this study can conclude only that the PALM-measured pectoralis minor length is valid for overhead-throwing athletes and may not be generalized to the public. In the future, research should be performed measuring pectoralis minor length with the PALM using different population sets to determine whether this difference still exists. Finally, this study had similar limitations as other studies using skin-based measures, including the inability to palpate due to the amount of subcutaneous fat over the anatomical landmark.[32,35]

This study was the first to determine the validity, reliability, and precision of the PALM-measured static pectoralis minor length in overhead-throwing athletes. The PALM was determined to be valid using criterion validity against the EMAS while the shoulder was in a resting position. Reliability of the PALM was determined to be excellent when the shoulder was at rest. The use of the PALM while measuring static pectoralis minor length is highly feasible in sports medicine and physical therapy clinics. It is a compact, low-cost device that can easily be stored in the clinic or even used when traveling. Thus, due to the importance of pectoralis minor length and the PALM's ease of use and cost-efficiency compared with the EMAS or other similar device, the PALM may be used by the clinician to gain easy, reliable, and objective measures of pectoralis minor length.

IMPLICATIONS FOR CLINICAL PRACTICE

The PALM is a versatile and relatively inexpensive tool that can be easily used to measure pectoralis minor length in overhead-throwing athletes. Due to the implications of shoulder injuries and the prevalence of altered scapular position in overhead-throwing athletes, measuring pectoralis minor length may be an important step in documenting changes in muscle length and preventing injury. Because the PALM was determined to be reliable, valid, and precise, we recommend that this tool be used to successfully measure pectoralis minor length in overhead-throwing athletes. ■

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