Original Article

Influence of Body Mass Index on Acromial Distance Evaluated in Sitting and Supine Positions: A cross-sectional study

Waleerat Sansee*, Chaowit Suttiwanit**, Varavee Temprom *,
Chamaiporn Sangnon*, Wanvisa Panichaporn***, Nitaya Viriyatharakij***

Abstract

Objective: 1) To analyse the effect of body mass index (BMI) on acromial distance (AD) evaluation in sitting and supine positions. 2) To clarify intra- and inter-rater reliability of AD evaluation.

Methods: A cross-sectional study was conducted by 4 well trained assessors in 2 Physical Therapy Faculties. A total of 114 healthy participants (aged 18–48 years old), comprising 20 males and 94 females. Participants were recruited through purposive sampling and separated into two groups according to BMI group 1 (BMI less than 23 kg/m2; n=69), and BMI group 2 (BMI greater than or equal to 23 kg/m^2; n=44). Main outcome measures were the AD evaluations in both sitting and supine positions were evaluated, and compared between BMI groups using independent-sample T Test.

Results: For participants in BMI group 1 and group 2, the average AD in the sitting position was 69.1 mm and 81.3 mm ($P < 0.001$), respectively. In the supine position, the average AD for participants in BMI group 1 and group 2 was 39.4 mm and 56.1 mm ($P < 0.001$), respectively. There was a statistically significant difference in AD values between the BMI groups ($P < 0.001$). The AD evaluations showed excellent both intra-rater reliability ($ICC_{3,1}$ 0.991 to 0.999) and inter-rater reliability ($ICC_{2,1}$ 0.954 to 0.999).

Conclusions: The AD values in both positions were significantly increased in the participants with a higher BMI. Therefore, BMI should be taken into account when using AD for clinical monitoring and interventions to correct pectoralis minor length or rounded shoulder posture.

Keywords: Acromial distance, Pectoralis minor length, Body mass index, Rounded shoulder posture

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* Faculty of Physical Therapy, Saint Louis Collage, Bangkok 10120, Thailand
** Faculty of Physical Therapy, Huachiew Chalermpraklet University, Samut Prakan 10540, Thailand
*** Faculty of Physical Therapy, Srinakharinwirot University, Ongkharak, Nakhon-nayok 26120, Thailand
Corresponding author: Nitaya Viriyatharakij Address: 63 Moo 6 Rungsit-Nakorn Nayok road, Ongkharak district, Nakhorn Nayok, Thailand 26120. E-mail address: nitayav@g.swu.ac.th

Introduction

The acromial distance (AD) is part of an evaluation used in clinical practice to determine the pectoralis minor (PMi) length.[1-3] The AD is the distance between the posterior border of the acromial angle and the wall (sitting) or bed (in supine). In the supine position, the body is supported lying on a bed; however, in a sitting position, the body is held upright against the force of gravity. Use of a sitting position to evaluate AD serves a specific purpose in clinical practice. A recent study published a comparison of AD while sitting to the conventional AD evaluated in supine.[4]

The PMi muscle, which lies between the 3rd to 5th ribs and the coracoid process, has been identified as one of the significant factors that affect AD. Tension of PMi in a shortened condition directly pulls on the coracoid process, tilting it into a more anteroinferior position. The shorter the PMi length, the longer the AD.[5] As a consequence, this causes greater compressive load on the soft tissues in the subacromial space.[6] The AD is also associated with a rounded shoulder posture.[7] Therefore, the AD is important for correcting posture and for the management of upper quadrant musculoskeletal pain. Other than PMi length, clinical decision-making based on the changes in AD also considers the potential effects of other associated and surrounding factors. These factors include personal factors such as body mass index (BMI), which is known to be associated with chest circumferences and dimensions.[8-10] The influence of BMI on AD prediction is further supported by the findings of Temprom et al.[4] These authors found that a BMI ranging from 21.4 to 23.2 kg/m^2 was significantly distributed as one predictor of AD in supine from sitting position. Thus, the effect of each unit change in BMI (as AD was held constant) caused an alteration between 0.7 to 1.7 mm of AD in the supine position. Accordingly, the effect of BMI on AD needs further clarification to define its range.

Controlling and minimising all sources of measurement error, including participants, assessors, postures, and protocols, is important for ensuring the accurate results. Thus, decision making in clinical practice should consider these sources of error. The minimal detectable change (MDC) represents the amount of error estimated in the measurement process.[11] Thus, it is important to determine the MDC of AD evaluations to confirm any differences. The objective of this study was to clarify the influence of BMI on AD in the supine and sitting positions. The intra-rater reliability, inter-rater reliability, and MDC95 of AD evaluations were performed to assess the clinical relevance of these evaluations.

Methods

Study design and participants

A cross-sectional design was employed for this study. The study objective and methods were clearly explained to all participants before they signed an informed consent form. Participants were recruited by purposive sampling from the staffs and students of a college, and was based on the following inclusion criteria: BMI greater than or equal to 16.4 kg/m^2, active full range of motion of the cervical and shoulder joints in all directions without pain, and had no past history of cervical and upper quadrant fracture or surgery. Participants with scoliosis or thoracic hyperkyphosis were screened as follows: (1) scoliosis, defined as a rib hump angle greater than 5 degrees,[12] confirmed using a scoliometre to evaluate the rib hump following Adam's forward bend test, in which the participant's knees were in extension and shoulders relaxed; and (2) thoracic flexed posture, defined by measuring the distance from the occiput to wall (OWD). Participants were excluded if the OWD was greater than 5 cm while standing normally with both knees extended against the wall as much as possible,[13] in which their back and buttocks could touch the wall but not lean on it. The OWD is the linear distance between the

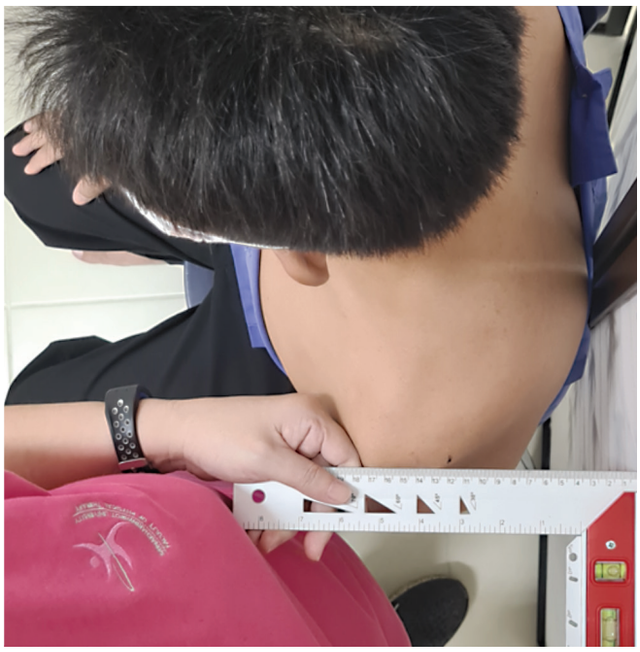
7th cervical spinous process and the wall, which was measured using a L-square ruler with a water level. Demographic data including age, weight, and height were also recorded. Ethical approval was provided by the Ethic Committee for Human research (PTPT2019-013).

Procedure

According to the method described by Temprom et al.,[4] the AD was evaluated on the dominant arm in both the sitting and supine positions, performed using a L-square ruler with a water level during exhalation. Four physical therapists (PT) were trained as assessors by a specialist (a physical therapy with more than 30 years of clinical experience). These assessors were taught how to palpate and accurately mark the acromion angle before measuring the AD. The steps of palpation were started by assessors gently pressed the index and middle finger on adjacent sides of the acromial angle. Then, they marked the most prominence of acromial angle and confirmed the accuracy from the specialist (Figure. 1). The inter-rater reliability of AD evaluation was determined based on data from 10 participants. For the sitting position, assessors W and C performed the AD evaluations. Then, assessors V, C, and CH performed the AD evaluations in the supine position. For the supine position, participants were instructed to lie on the bed without a pillow or a towel to support their neck. They were asked to breathe normally, slightly flex their elbows and place their hands over their abdomen in order to reduce the tension of the biceps brachii muscle.[1] The AD in each position was evaluated twice independently. A research assistant recorded each measurement in a separate datasheet. Thus, the previous results were blinded from both the assessors and research assistants. The mark on the acromion angle was removed after each evaluation to prevent assessor bias. Participants were allowed 3 minutes rest before starting another round of evaluation. Consequence of lying in supine position may cause a stretching effect on pectoral soft tissue. Thus, the AD evaluations were performed firstly in the sitting position then in the supine position (Figure. 2).

Figure 1 Palpation and marking on acromial angle in supine position

A.



B.

Figure 2 Acromial distance evaluated in in sitting (A) and in supine position (B)

Data analysis

IBM SPSS software for Windows (version 23.0; IBM Corp., Armonk, NY, USA) was used to analyse the data, with a statistically significant difference set at $P < 0.05$. Demographic data including age, sex, weight, height, and BMI were presented as the mean and standard error (SE). The intra- and inter-rater reliability of the AD evaluations were analysed by intraclass correlation coefficient models 3,1 ($ICC_{3,1}$) and 2,1 ($ICC_{2,1}$), respectively. The standard error of measurement (SEM) was calculated as SD × √(1 - ICC). Additionally, a minimal detectable change was defined at the 95% confidence level (MDC_{95}) and calculated as SEM × 1.96 × √2 (10). For each position, T-tests (unequal variances) was used to analyse the differences in AD evaluations between participants in BMI group 1 and 2 (defined as less than 23 kg/m^2 and greater than or equal to 23 kg/m^2, respectively). This BMI categories were based-on the classification for Asians.[14]

Results

In total, 114 healthy participants, consisting of 20 males and 94 females, were deemed eligible for the study. The age range of participants was 18 to 48 years old, and the average weight, height, and BMI were 60.5 kg, 160.7 cm, and 23.3 kg/m^2, respectively. Characteristics of the eligible participants were presented by BMI groups (Table 1). The intra-rater reliability for AD ranged from 0.991 to 0.999 and the inter-rater reliability ranged from 0.954 to 0.999. All ICCs were higher than 0.9 (Table 2).

Table 1 Characteristics of eligible participants in this study

Group	Participants N (%) Male/ Female	Mean	SE	Min	Max
1	69(61.1)				
BMI < 23	11(15.9)/58(84.1)				
Age (year)		24.5	0.8	18.0	48.0
Weight (kg)		52.4	0.8	42.0	70.0
Height (cm)		160	0.7	148.0	175.0
BMI (kg/m^2)		20.4	0.2	16.4	22.9
2	44(38.9)				
BMI ≥ 23	9(20.5)/35(79.6)				
Age (year)		27.3	1.0	19.0	45.0
Weight (kg)		73.1	2.2	58.0	142.0
Height (cm)		161.8	1.1	150.0	178.0
BMI (kg/m^2)		27.9	0.7	23.1	47.5

Abbreviations: BMI – body mass index; SE - Standard Error

Table 2 Intra and Inter-rater reliability of acromial distance from sitting and supine positions

Position	Assessor	ICC	95% CI		SEM (mm)		MDC95 (mm)	
			Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Intra-rater reliability ($ICC_{3,1}$)								
Sitting	1	0.998	0.991	0.999	0.34	1.33	0.95	3.70
	2	0.998	0.992	0.999	0.30	1.15	0.83	3.20
Supine	2	0.999	0.997	0.999	0.43	0.43	0.20	1.20
	3	0.999	0.996	0.999	0.44	0.44	0.22	1.22
	4	0.999	0.999	0.999	0.44	0.44	0.21	1.21
Inter-rater reliability ($ICC_{2,1}$)								
Sitting	1 and 2	0.989	0.954	0.997	0.74	2.88	2.04	7.99
Supine	2,3 and 4	0.999	0.998	0.999	0.42	0.66	1.17	1.83

Abbreviations: Assessor - 1 was W, 2 was C, 3 was V, 4 was CH; ICC - Intraclass Correlation Coefficient; 95%CI - 95% Confidence Interval; SEM - Standard error of measurement; MDC95 - Minimal detectable change at 95% confidence interval

The comparison between BMI groups revealed a statistically significant difference in AD in both sitting ($P < 0.001$) and supine ($P < 0.001$) positions. In sitting, the average AD of participants was 69.1 mm (95% CI [66.0, 72.2]) in the group with a BMI less than 23 kg/m^2 and 81.3 mm (95% CI [76.0, 86.5]) in the group with a BMI of greater than or equal to 23 kg/m^2. In the supine position, the average AD of participants with a BMI lower than 23 kg/m^2 was 39.4 mm (95% CI [36.9, 42.0]) while the AD for those with a BMI greater than or equal to 23 kg/m^2 was 56.1 mm (95% CI [51.6, to 60.5]; Table 3).

Table 3 The average of AD evaluation in sitting and supine position categorized for participants in BMI group 1 (< 23 kg/m^2) and group 2 (≥ 23 kg/m^2)

BMI group	Participants n (%)	AD (mm)				*P*-value
		Mean	SE	95% CI		
				Lower Bound	Upper Bound	
Sitting position group						
1	69 (60.5)	69.1	1.5	66.0	72.2	<0.001
2	44 (39.5)	81.3	2.6	76.0	86.5	
Supine position group						
1	69 (60.5)	39.4	1.3	36.9	42.0	<0.001
2	44 (39.5)	56.1	2.2	51.6	60.5	

Abbreviations: BMI – body mass index; *P*-value from unequal variances t-test; AD - acromial distance; 95%CI - 95% Confidence Interval; SE - Standard error

Discussion

The results of the present study showed excellent intra- and inter-rater reliability of AD evaluations in the sitting and supine positions (ICC range 0.954 to 0.999). This study revealed a wider MDC_{95} range than that reported by Temprom et al.,[4] which may be attributed to greater difficulty of palpation in participants with a higher BMI, together with a greater number of assessors in the current study. However, the results showed a statistically significant difference between the two BMI groups ($P < 0.001$) which was greater than the MDC_{95} range. This confirms that the differences observed were not due to measurement error. For both the sitting and supine positions, participants in the group with a BMI equal to or higher than 23 kg/m^2 had a longer AD than those with a BMI less than 23 kg/m^2. Thus, the higher the BMI, the greater the AD. This association was supported from the previous studies that BMI was associated with chest circumferences and dimensions.[8–10] Based-on a cut-off value for PMi tightness equal to 2.54 cm (or 25.4 mm), reported by Sahrmann[1] and supported by other studies,[2, 15] only eight participants in our study had an AD less than 25.4 mm. One of them had a BMI of 24.52 kg/m^2, while the other seven participants had a BMI within the range less than 23 kg/m^2. This occurrence may correspond to the contribution of BMI and AD in sitting position for AD in supine.[4] In the multiple regression model[4], BMI was a predictor for AD in supine and shared 41.4%. Therefore, the interpretation of PMi length followed this cut-off have to concern the effect of BMI as making a clinical decision to progress any intervention for improving PMi length or rounded shoulder posture.

The findings of the current study support the results of the previous study despite the wider BMI range studied (16.4 to 47.5 kg/m$_2$). In conclusion, BMI should be included as an influencing factor when the PMi length is evaluated by using AD evaluations.

Limitation of the study

The AD may be associated with the stiffness of the PMi that is reflected by a difference in AD between active scapular retraction and resting in a relaxed position. However, AD may be alteration in BMI related factors, particularly sex or age. Accordingly, the effect of BMI on PMi lengthening interventions should be clarified in addition to a circumstance of PMi stiffness, sex or age in a further study.

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บทคัดย่อ

อิทธิพลของดัชนีมวลกายต่อการประเมิน Acromial Distance ในท่านั่งและท่านอน: การศึกษาแบบภาคตัดขวาง

วลีรัตน์ สันสี*, เชาว์นวิทย์ สุทธิวานิช, วรวีร์ เต็มพร้อม*, ชไมพร แสงนนท์**, วันวิสาข์ พานิชาภรณ์***, นิตยา วิริยะธารากิจ*****

* คณะกายภาพบำบัด วิทยาลัยเซนต์หลุยส์ กรุงเทพมหานคร 10120 ประเทศไทย

** คณะกายภาพบำบัด มหาวิทยาลัยหัวเฉียวเฉลิมพระเกียรติ สมุทรปราการ 10540 ประเทศไทย

*** คณะกายภาพบำบัด มหาวิทยาลัยศรีนครินทรวิโรฒ องครักษ์ นครนายก 26120 ประเทศไทย

ผู้ให้การติดต่อ: นิตยา วิริยะธารากิจ 63 หมู่ 6 ถนนรังสิต-นครนายก คณะกายภาพบำบัด มหาวิทยาลัยศรีนครินทรวิโรฒ องครักษ์ นครนายก 26120 ประเทศไทย

วัตถุประสงค์: 1) วิเคราะห์ผลของดัชนีมวลกายต่อการประเมิน acromial distance (AD) ในท่านั่งและท่านอน 2) หาความเชื่อถือได้ภายในผู้ประเมิน (intra-rater reliability) และระหว่างผู้ประเมิน (inter-rater reliability) ของการประเมิน AD

วิธีการศึกษา: การศึกษาด้วยวิธีวิจัยแบบภาคตัดขวางดำเนินโดยผู้ประเมินที่ได้รับการฝึกอย่างดี 4 คน ในคณะกายภาพบำบัด 2 แห่ง อาสาสมัครสุขภาพดีจำนวน 114 คน (อายุ 18-48 ปี) ประกอบด้วยเพศชาย 20 คน และเพศหญิง 94 คน ได้รับการคัดเลือกด้วยวิธี purposive sampling และแบ่ง 2 กลุ่มตามค่าดัชนีมวลกาย (BMI) เป็น BMI กลุ่ม 1 (BMI น้อยกว่า 23 kg/m^2; n=69) และ BMI กลุ่ม 2 (BMI เท่ากับหรือมากกว่า 23 kg/m_2; n=44) ผลลัพธ์สำคัญของการศึกษา คือ การประเมิน AD ในท่านั่งและท่านอน ทำการวิเคราะห์และเปรียบเทียบระหว่างกลุ่มของ BMI ด้วย independent-sample T-Test

ผลการศึกษา: อาสาสมัครใน BMI กลุ่ม 1 และกลุ่ม 2 มีค่าเฉลี่ยของ AD ในท่านั่งมีค่า 69.1 มม. และ 81.3 มม. ตามลำดับ ($P < 0.001$) ในท่านอน อาสาสมัครใน BMI กลุ่ม 1 และกลุ่ม 2 มีค่าเฉลี่ยของ AD ในท่านั่งมีค่า 39.4 มม. และ 56.1 มม. ตามลำดับ ($P < 0.001$) โดยมีความแตกต่างอย่างมีนัยสำคัญทางสถิติในค่า AD ระหว่างกลุ่มของ BMI ($P < 0.001$) การประเมิน AD มีค่าความเชื่อถือได้ในระดับดีมากทั้งภายในผู้ประเมิน (intra-rater reliability; $ICC_{3,1}$ 0.991 to 0.999) และระหว่างผู้ประเมิน (inter-rater reliability; $ICC_{2,1}$ 0.954 to 0.999)

สรุปผลการศึกษา: ค่า AD ทั้ง 2 ท่ามีค่าเพิ่มขึ้นในอาสาสมัครที่มี BMI สูงกว่า ดังนั้น ควรนำ BMI ไปพิจารณาร่วมเมื่อใช้ AD ในการติดตามตรวจสอบทางคลินิกและการรักษาเพื่อแก้ไขความยาวของกล้ามเนื้อหน้าอกมัดเล็กหรือไหล่งุ้ม

คำสำคัญ: Acromial distance, ความยาวกล้ามเนื้อหน้าอกมัดเล็ก, ดัชนีมวลกาย, ท่าไหล่งุ้ม