Reliability of visual estimation of angles relating to joint ranges of motion in rehabilitation

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Introduction

How much confidence should we have in the ranges of motion that we measure using visual estimation (VE)?

Clinicians commonly estimate ranges of motion (ROM), such as hip flexion or knee extension, as a measure of muscle stiffness or contracture. These ROMs can be performed actively (by the patient) or passively (by the clinician). The angles are frequently recorded to the nearest 5 , without the use of an instrumented measuring device, such as a goniometer.

These visual estimations (VE) are thought to speed up clinical assessment times and reduce the need for an additional clinician to assist with supporting the limb whilst a measuring device is manipulated. Additionally, with patients having profound physical disabilities, bony landmarks are often in a significantly altered position to normal, making instrumentation either extremely difficult to use or invalid.

This study was developed due to a clinical need to test the reliability and validity of using VE when recording the ROM of a patient's limbs. In postural management services inaccuracies may lead to the manufacture or prescription of inappropriate seating, wasting both time and money; it may also not provide sufficient reliability of measures between clinicians, which is important for continuity.

Methods

Ethical approval for this study was given by the University of Surrey Ethics Committee.

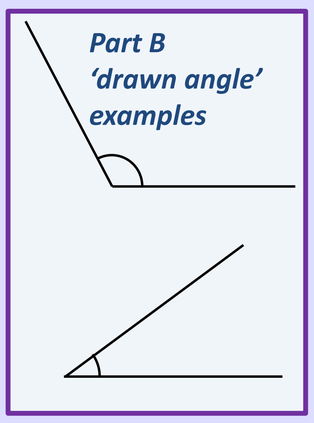
Data was collected over two sessions by clinicians working in physical rehabilitation services at the Nuffield Orthopaedic Centre (NOC) in Oxford. A slightly amended collection method was used to collect results over two sessions from Postgraduate Posture Management students.

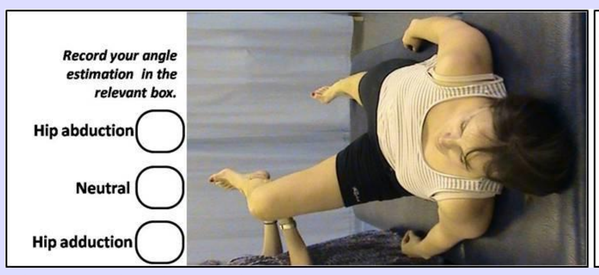
The study consisted of 3 main parts.

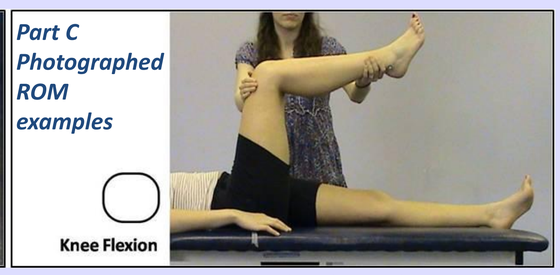
Part A was a **questionnaire** completed in session 1 only. Each participant was asked six questions; 2 questions related to the participant (profession and department) and 4 related to their experience (confidence, method, frequency and years of experience using VE)

Part B consisted of 25 randomly generated **drawn angles**, presented on separate leaves of a booklet.

Part C presented 15 digital **photographs**, each of a positioned limb. Participants were asked to estimate a specific range, e.g. hip flexion according to the Neutral-O method [1].







The method employed aimed to present some evidence as to whether clinicians are able to estimate angles without the additional errors associated with ROM estimation in a clinical setting.

(Results 1) Overall Accuracy

The percentage of all estimations in each part of the study that were within 5° and 10° were calculated. This showed, as expected, a higher reliability in estimations from the drawn angles than the photographs.

Error from true value	This study		Moran et al. [2]	Abu Rajab et al. [3]
	Part B	Part C	12 drawn angles (like part B)	21 digital images (like part C)
± 5°	80.3%	61.5%	64.6 %	70.8%
± 10°	95.6%	81.9%	93.1%	Not reported

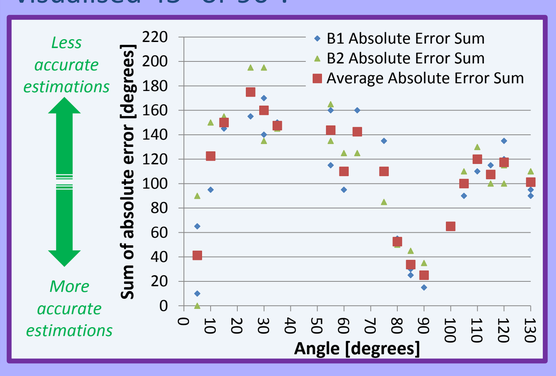
(Results 2) Effect of angle magnitude

As seen below, angles less than 35° were consistently overestimated (blue boxes). 43% of these angles were overestimated by 5°, 17% by 10° and 7% by 15°. This finding has implications particularly for ranges of motion which are typically acute, such as hip ab/adduction.

Blue boxes represent overestimations, and purple boxes are underestimations. Each column shows a single participant's responses to the drawn angles.
AA=Actual angle, CPA= Correct predicted angle (i.e. AA to the nearest 5°)

AA	CPA	Participant Identification Numbers																													
		001	002	003	004	005	006	007	008	010	011	013	014	015	017	020	023	024	027	028	032	035	037	038	040
5	5	0	5	5	0	0	0	5	5	0	5	5	5	5	0	5	5	0	5	5	5	0	0	0	0
10	10	0	5	10	5	0	-5	5	5	5	5	5	5	5	0	10	0	5	0	0	15	-5	0	0	0
15	15	0	0	10	5	5	-5	15	5	5	5	15	0	5	5	10	0	5	5	10	15	10	0	5	-5
26	25	0	5	5	10	10	0	5	5	5	5	15	0	0	5	15	5	5	5	10	15	5	-5	10	10
28	30	0	5	0	5	0	-5	5	0	5	10	10	0	0	5	15	10	5	10	-5	15	-10	0	5	15
31	30	5	5	10	10	0	0	15	5	10	10	10	0	5	10	15	0	10	10	0	10	5	-10	5	10
36	35	5	5	5	5	-5	-5	5	5	10	10	-5	5	5	5	0	10	10	0	20	5	-5	5	10	
53	55	-5	10	5	10	5	-5	-5	5	-5	5	-5	-5	-5	0	5	10	5	10	-10	15	5	-5	10	10
55	55	-5	0	5	20	0	-5	-5	0	0	10	-5	-5	0	0	5	5	5	10	5	10	-5	-5	0	5
60	60	-5	0	0	5	5	0	0	0	0	0	-5	-5	-5	0	0	10	5	5	0	20	10	0	-5	10
63	65	-5	0	5	5	5	-5	-10	0	-5	-5	-10	-10	0	-5	5	5	-5	-15	10	10	15	5	-5	15
76	75	-5	0	0	5	0	5	5	0	5	5	-35	5	-5	-5	0	5	5	5	0	10	10	5	5	10
81	80	0	0	0	5	5	0	5	0	0	5	0	-5	-5	-5	0	0	5	0	0	0	5	5	0	5
84	85	0	0	0	0	0	0	0	0	0	0	-5	-5	-5	0	0	0	0	0	0	0	0	0	0	10
87	85	0	0	0	5	5	0	0	-5	0	0	0	0	0	0	0	0	5	5	0	0	0	5	0	0
89	90	-5	-5	0	0	0	0	0	0	0	0	0	-5	0	0	0	0	0	0	0	0	0	0	0	0
101	100	0	10	0	0	0	0	-5	0	0	0	-5	0	0	0	5	0	-5	0	0	5	-5	10	10	-5
106	105	0	5	0	0	0	0	-5	10	5	-5	-5	10	0	5	0	-5	10	0	-5	-10	0	0	5	
112	110	0	-5	10	-10	0	0	0	10	5	0	0	0	5	5	-5	15	-10	5	0	5	-10	10	0	0
116	115	-5	5	5	0	-5	-15	5	0	0	5	5	5	10	10	0	0	-10	5	5	-5	-10	5	0	0
118	120	-10	-5	0	-15	-5	0	0	10	0	-5	0	0	-10	-5	-10	-10	-10	0	-5	-5	-20	5	0	-5
122	120	0	-5	10	-5	0	-5	0	0	0	0	5	5	5	0	10	5	-5	5	5	-10	-10	-5	5	20
128	130	-10	0	-5	-5	-5	0	0	0	5	0	0	-5	0	5	10	0	-10	5	0	-10	-10	-5	0	5
129	130	0	-5	0	-10	0	0	0	5	-5	-5	0	-5	0	-5	5	0	-10	0	0	-10	-20	0	0	5

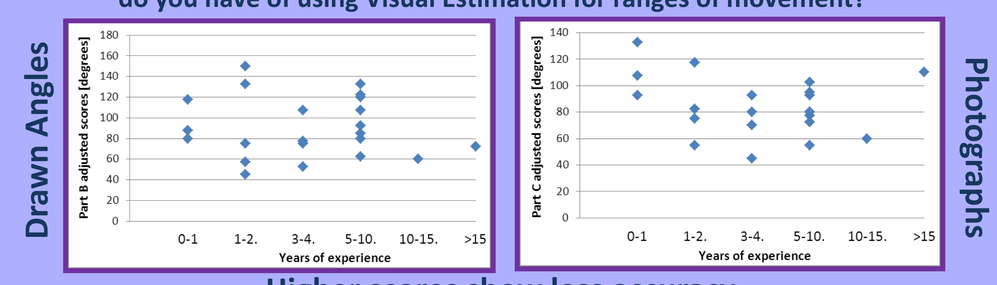
As could be expected the error sum for those angles near to 90° was particularly low. When discussing results with participants the majority did estimate angles compared to a visualised 45° or 90°.



(Results 3) Effect of profession and experience

Due to small group numbers a visual comparison of data subdivided by questionnaire responses (e.g. profession, years of experience) was carried out: The majority of the items showed little correlation with the error scores that were calculated for each participant for either the drawn angles or photographs in either session.

Q6. Approximately how many years experience do you have of using Visual Estimation for ranges of movement?



Higher scores show less accuracy

Results and Conclusions

A total of 24 people participated in the study (15 in the original study, and 9 from the Postgrad course). Each participant was given two overall measures of accuracy, for each part and for each session.

1. Sum error = total of absolute errors ('true result' – estimation)

2. Adjusted sum error = sum error – largest error – smallest error.

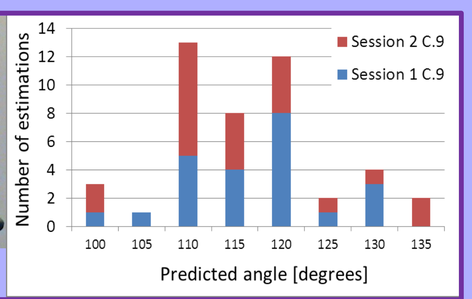
The total sum error for each angle was also calculated. The results from each session were compared on a Bland Altman plot and showed no obvious learning effect between sessions.

For the photographs the 'true angle' was calculated as the angle drawn between joint centers, as shown by reflective markers placed and then edited out prior to data collection.

(Results 4) Effect of angle required

Histograms produced for estimations from each photograph suggest a tendency for estimations to the nearest 10°. 65% (session 1) and 75% (session 2) of estimations ended in a 0 digit, compared to 40% if all estimations made correctly.
This could suggest that although protocol is to estimate ranges to the nearest 5°, many clinicians in practice estimate to the nearest 10°.

True angle 115°



Application to clinical practice

This study produced no evidence to show that accurate visual estimation of joint ranges of motion was a skill acquired over time. Results, however, did suggest that smaller angles of less than approximately 35 were consistently over estimated. 81.9% of estimations from photographs were correct to within 10 .
Individual departments would need to consider whether this makes VE a suitably reliable measure. These levels of accuracy should also be considered when using VE to make comparisons between measures gained at different times and by different clinicians for a single client.

References

[1] [5] Ryf C, Wymann A. Range of Motion - AO Neutral-0 Method. 1st Edition ed.: Thieme Stuttgart, Germany; 1999.
[2] Moran KM, Ness K, A AF. Visual estimation of angles by orthopedic surgeons. American journal of orthopedics (Belle Mead, N.J.) 2000 05;29(5):361-2; discussion 363.
[3] Abu-Rajab RB, Marsh A, Young D, Rymaszewski LA. Visual estimation of joint angles at the elbow. Eur.J.Orthop.Surg.Traumatol. 2010;20(6):463-467.

Acknowledgements

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