Journal of Electromyography and Kinesiology 29 (2016) 81–89

Contents lists available at ScienceDirect

Journal of Electromyography and Kinesiology

journal homepage: www.elsevier.com/locate/jelekin

The Constant score and the assessment of scapula dyskinesis: Proposal and assessment of an integrated outcome measure

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ARTICLE INFO

Article history:
Received 18 December 2014
Received in revised form 25 May 2015
Accepted 30 June 2015

Keywords:
Scapula
Dyskinesis
Rotator cuff
Surgery
Shoulder pain
Outcome measure

ABSTRACT

The Constant–Murley score (CMS) is a popular measure of shoulder function. However, its ability to monitor the evolution of patients during rehabilitation after rotator-cuff repair is controversial. Moreover, CMS does not account for possible alterations in the scapulo-humeral coordination (SHC, scapula dyskinesis), which are apparent in variety of shoulder pathologies. To address these issues, a new formulation of CMS was firstly proposed, which rates the "affected-to-controlateral side difference in SHC" of a patient with respect to reference values of asymptomatic controls (Scapula-Weighted CMS). Then, 32 patients (53 ± 9 year-old) were evaluated with CMS and SW-CMS at 45, 70, 90-day and >6-month after rotator-cuff repair, to test three hypotheses: (1) CMS and SW-CMS are largely responsive to change; (2) accounting (SW-CMS) or not (CMS) for scapula dyskinesis leads to statistically different scores and SW-CMS cannot be predicted from CMS without clinically relevant differences; (3) 90% of patients recover a side-to-side SHC similar to asymptomatic controls at 90 days. Results supported hypotheses 1 and 2. On the contrary (hypothesis 3), only 10% of patients recovered for SHC alterations at 90 days, and 50% at follow-up. These findings support the use of SW-CMS and the importance of treating scapula dyskinesis after rotator-cuff repair.

1. Introduction

The ability to measure the impairment and activity level of patients with shoulder disorders is clinically relevant, e.g. to manage or refine their expectations during rehabilitation and to compare the efficacy of alternative treatments. For this purpose, a variety of clinical scores have been proposed in the literature (Kirkley et al., 2003; Wylie et al., 2014). Among them, the Constant–Murley Score (CMS) (Constant and Murley, 1987; Constant et al., 2008) has become one of the most popular, both in Europe (Constant, 1991; Kirkley et al., 2003; Varghese et al., 2014) and in the USA (Provencher et al., 2014).

CMS has both self-reported (pain and daily living activities) and performance-based items (shoulder mobility in elevation/rotation and strength); 35 points are allocated for subjective assessments and 65 points for objective evaluations, leaving a total score from 0 (worse score) to 100 points (maximum score). If a standard of application is established and experienced raters are involved, CMS showed acceptable overall psychometric properties (Blonna et al., 2012; Fialka et al., 2005; Kukkonen et al., 2013; O'Connor et al., 1999; Rocourt et al., 2008; Roy et al., 2007; Wylie et al., 2014).

Nevertheless, some relevant issues are still open. *First*, very little is known about the responsiveness of CMS during rehabilitation (O'Connor et al., 1999), i.e. its ability to change over a predefined, clinically meaningful, timeframe (Husted et al., 2000), with no evidences after rotator-cuff surgery. If CMS was proved responsive enough, it might be used to tune treatments or predict the final outcome from early stage assessments. *Second*, the items of CMS

Abbreviations: AB–AD, abduction–adduction; CMS, Constant–Murley Score; ES, effect size; IN–EX, internal–external rotation; FL–EX, flexion–extension; MCID, Minimal Clinically Important Difference; ME-LA, medio-lateral rotation; P–A, anterior–posterior tilting; PR–RE, protraction–retraction; SHC, scapulo-humeral coordination; SW-CMS, Scapula-Weighted Constant–Murley Score.

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http://dx.doi.org/10.1016/j.jelekin.2015.06.011
1050-6411/

do not *explicitly* account for alterations in the scapulo-humeral coordination (SHC), i.e. scapula dyskinesis (Kibler et al., 2013; Cools et al., 2013): no items are included in the score and the examiner is not asked to assess scapula movements. The immediate consequence can be a misclassification of patients: by just considering the humero-thoracic motion, a patient can be assigned the same rating despite an altered scapula protraction–retraction (PR–RE), medio-lateral rotation (ME-LA) or anterior–posterior tilting (P–A). Ultimately, this can lead to wrong rating of the outcome of interventions and suboptimal rehabilitation treatments (Kibler et al., 2013).

Scapula dyskinesis was described in association with a variety of shoulder pathologies, including impingement, rotator-cuff tear, adhesive capsulitis, glenohumeral osteoarthritis and post-stroke (Ludewig and Reynolds, 2009; De Baets et al., 2013). Its origin was related to pain, soft tissue stiffness, muscle recruitment pattern, force imbalance, muscle fatigue, thoracic postures, and it was reported as either a cause or an effect of shoulder pathologies (Ludewig and Reynolds, 2009; De Baets et al., 2013; Cools et al., 2013; Reuther et al., 2014). Despite the on-going debate, consensus exists that scapula dyskinesis is a potential impairment to shoulder function, that its assessment should be a routine part of the shoulder examination, and that addressing dyskinesis in the framework of a rehabilitation program improves outcomes (Kibler et al., 2013; McClure et al., 2012). Ultimately, the quantitative measure of shoulder dyskinesis can help in moving away from the too generic diagnostic label of 'shoulder impingement", in favor of movement-based diagnostic categories that can help in treatment planning (Braman et al., 2014).

The first aim of this study is to propose a modification of CMS, by weighting the points assigned to the humero-thoracic elevation, depending on the "affected-to-controlateral side difference in SHC" being greater than the typical difference in asymptomatic controls. The modified score will be named herein Scapula-Weighted Constant–Murley Score (SW-CMS).

Then, assuming a group of patients monitored during the rehabilitation after rotator cuff surgery, it was hypothesised that:

(1) CMS and SW-CMS change by a large amount during rehabilitation, i.e. they can be used to monitor the evolution of patient over treatments.
(2) CMS items do not *implicitly* account for scapula dyskinesis, i.e. SW-CMS and CMS scores are significantly different, and SW-CMS cannot be predicted from CMS without clinically important differences; in other words, CMS provides a partial assessment of shoulder impairment.
(3) A large amount of patients recover a side-to-side SHC similar to asymptomatic controls at 90 days post-surgery, i.e. 90 days represents a turning point for recovery.

2. Methods

2.1. Development of the Scapula-Weighted Constant–Murley Score

2.1.1. The Constant–Murley Score (CMS)

CMS assigns 100 points to a shoulder through assessments in 4 domains: movement (40), strength (25), activities of the daily living (20) and pain (15). The assessment in the movement domain requires the clinician to measure internal (10) and external rotation (10) and the degree of humero-thoracic elevation in the frontal (10) and sagittal plane (10).

In its original formulation, CMS was poorly described. To ensure optimal results (Blonna et al., 2012), the same rater should assess each patient over time and raters should agree on a standardized procedure. If these precautions are applied, the intra-rater agreement is less than 10 points (Rocourt et al., 2008; Blonna et al., 2012), which is comparable to the Minimal Clinically Important Difference (MCID) reported for patients undergoing rotator cuff surgery (Kukkonen et al., 2013). Therefore, when these patients are of interest, 10 points appear a valid threshold to assess the responsiveness of the scale to change.

CMS is typically normalized either based on reference values reported in (Constant et al., 2008) (Relative Constant–Murley Score), or based on the score of the contralateral side (Fialka et al., 2005) (Individual Relative Constant–Murley Score). Fialka and co-workers proved that this latter solution increases the sensitivity and specificity of the score, and reported that it more closely reflects the patient-specific expectation. Based on these conclusions, in the present study the contralateral side normalization was assumed, which required assessing both sides of each patient. When completing the assessment for the contralateral side, patients were asked to answer to item #2 of CMS (unaffected sleep, full recreation/sport, full work), as if both shoulders were like the contralateral, i.e. as if the affected side could perform as the other side.

Based on Iannotti et al. (1996), we assumed the following qualitative interpretation for the scores of CMS: excellent (90–100), good (80–89), fair (70–79), poor (<70).

2.1.2. Measurement of SHC and side-to-side reference values

In order to modify CMS to account for alterations in the SHC, two pre-requirements must be satisfied:

a. The measure of SHC should be easy to perform in an outpatient setting, to retain the ease of application of CMS as much as possible.
b. A quantitative normative reference must be available for the typical difference in SHC between sides in asymptomatic subjects.

ISEO® (INAIL Shoulder and Elbow Outpatient protocol) (Cutti et al., 2008, 2014; Parel et al., 2012, 2014) is the only published motion analysis protocol that satisfies these conditions, at present. By using three inertial & magnetic measurement units (MT sensors – Xsens Technologies, NL) positioned over thorax, scapula and humerus (Fig. 1), and following a static calibration, ISEO provides scapula and humerus orientations relative to the thorax in terms of Euler angles (Cutti et al., 2008). The scapula orientation is expressed in terms of PR–RE, ME-LA and P–A, while the humerus orientation in terms of flexion–extension (FL–EX), abduction–adduction (AB–AD) and internal–external rotation (IN–EX) for sagittal plane movements; AB–AD, FL–EX and IN–EX for the frontal plane movements (Kontaxis et al., 2009).

If both sides of a subject are measured during frontal and lateral elevations, the side-to-side difference in SHC can be represented by Cutti et al. (2014) (Fig. 2):

(1) 3 scalar values for PR–RE, ME-LA and P–A, representing the difference in scapula resting position.
(2) 6 angle-angle plots, representing the difference in ROM variation of PR–RE, ME-LA, P–A vs FL–EX during humerus forward and backward flexion in the sagittal plane.
(3) 6 angle-angle plots, as in (2) but considering humerus AB-AD during lateral elevation movements.

By extracting this information on a group of 36 asymptomatic subjects (42 ± 13 year old; 21 male) and applying a Bootstrap method, Cutti et al. (2014) established a reference set of "differential" prediction bands (for scapula motion) and intervals (for scapula resting position) based on ISEO. Thanks to the specific properties of the Bootstrap method, if the difference between the sides of a new subject is outside one of the asymptomatic intervals