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A Novel Cervical Range of Motion Test to Measure Restricted Combined Movements. Preliminary Pre-Post Intervention Study

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Abstract

Background: Neck stiffness and limited range of motion in the neck can be painful and can impede performing activities of daily living (ADL). General cervical range of motion (CROM) tests are considered accurate assessment of neck movements. However, traditional CROM tests are performed in the sagittal, transverse and frontal planes but neck movements performed in ADL involves mostly combined movements. The CROM-Quarter test is a brand-new test which measure in which of the four quarter(s) or quadrant(s) patient with neck pain has the most restricted movements in 2-dimensional space. Consequently, the clinician can direct the mobilizing treatment more precisely to the movements of the most restricted cervical quadrant(s) and essentially give more effective treatment and potentially shorten the treatment period.

Objective: To ascertain if CROM-Quarter test can be used pre- and post- intervention to document the effects of a single mobilizing treatment session in clinical practice.

Methods: Twenty individuals, ages 18-50 years, with a primary complaint of stiff neck participated. An experienced physical therapist performed the mobilizing treatment for 30 minutes but participants were measured with the CROM-Quarter test immediately before and after treatment of the single most restricted quadrant at the time of the visit. The Oculus Go, a virtual reality headset, was used in this study. The reason was that CROM is too large to perform movements and use a computer screen, therefore the participants had the screen on the head (in front of their eyes) to be able to perform maximal movements of their necks.

Results: Percent increase in area of x and y co-ordinates on the computer screen were calculated, which consists of the total area that an individual could cover within each area (quarter). Paired t-test showed signifcant difference between pre-post measurements ($p<0.001$) or mean 106% ± 38% improvement. The intra-rater reliability was moderate – excellent.

Conclusion: The results indicated that the CROM-Quarter test can be used to document the effects of a single mobilizing treatment session in clinical practice. Quantifying the progress and outcome of clinical care after each treatment session contributes to value-based health care, which is very much requested in the Western world.

Keywords: Cervical range of motion; Measurement; Neck sti ness; Neck pain; Assessment

Abbreviation: CROM: Cervical Range of Motion; ADL: Activities of Daily Living; ICC: Intraclass Correlation Coe cient; Con dence Interval: CI; SEM: Standard Error of Measurement; VAS: Visual Analogue Scale; IMU: Inertial Measurement Unit

Introduction

Neck pain is a costly and common health problem which can be of insidious onset or can follow a trauma [1,2]. In the adult general population, which peak incidence coincided with middle-age groups peaking at ages 40-49 and ages 35-44, respectively, with typical 12-month prevalence estimates from 30-50% having neck pain [3]. Incidence of self-reported neck pain in the general population is 213 per 1000 persons [3]. e annual incidence of whiplash-associated disorders in North-America and Western Europe is estimated to be at least 300 per 100,000 inhabitants [4]. e number of individuals who seek emergency room treatment for tra c-related whiplash disorders has been on the rise over the past 30 years [5]. In 2015 more than 330 million people in the world had neck pain that lasted longer than 3 months [6]. Neck pain and low back pain combined are the fourth leading cause to years lived with disability in the world just a er ischemic heart disease, cerebrovascular disease, and lower respiratory infection [6]. e nancial burden that follows disability due to neck pain urges the need to develop outcome measures when assessing clinical progress [7]. Neck pain resulting in limited range of motion, can a ect normal activities of the individual patient and lower quality of life [8,9]. Traditional cervical range of motion (CROM) tests are performed in the sagittal, transverse and frontal planes but neck movements performed in ADL involve mostly combined movements. Clinical experience indicates that patients with neck pain usually have restricted movements in combined planes. Until now, CROM tests that measures movements in combined planes has not existed.

In clinical practice there are several methods used to measure CROM in straight planes, including visual estimation, CROM-device, universal goniometer, tape measure assessment and others [10]. It has been demonstrated that a universal goniometer and visual estimation show poor-to-fair inter-tester reliability in repeated measurements while the CROM device was the most reliable testing instrument of

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those three methods [11]. A simple CROM device consists of 3 uid-dampened inclinometers, one for each plane of motion, transverse, sagittal and frontal plane [8,12]. e inclinometers, two gravitational and the third magnetic are secured to a lightweight, plastic frame which ts on the head. To avoid accessory movements of the trunk and shoulder girdle, verbal instructions are given, however those may not be adequate. e examiner reads o the inclinometer and writes the results down. is may be considered too cumbersome in use, which is the problelu the

clinical characteristics of the participants at baseline. e primary outcome measure in the study, the CROM-Quarter test, was obtained through the NeckSmart so ware, in the ownership of NeckCare Holding ehf. e Oculus Go, a virtual reality headset, was used in this study. e reason was that the cervical range of motion is too large to perform movements and use a computer screen, therefore the participants had the screen on the head (in front of their eyes) to be able to perform maximal movements of their necks. An Inertial measurement unit (IMU sensor) was placed on the head and secured by a headgear. e IMU sensor is wireless and connected to NeckSmart so ware via Bluetooth and measures the various movements of the neck during the test in real time. is test measures the quantity of range of motion (ROM) in each of the four (4) quarters of total ROM in – 2-dimensional space: Upper Quarter Le ; Upper Quarter Right; Lower Quarter Le : Lower Quarter Right. e outcome was calculated as percentage increase in area of x and y co-ordinates on the computer screen, representing the total area the patient could cover in each quarter/quadrant.

Procedure

Participants received written and verbal information about test procedures and informed consent was obtained. e participants were asked to answer pain and disability questionnaires before the test. e same research assistant performed the testing pre-post intervention. e patient was seated in a chair and strapped to the chair to avoid accessory movements of the trunk and shoulder girdle during the test. e Oculus Go headset and IMU sensor was placed on the participants' head and instructions on how to perform the test were given. e headset provided visual feedback and guided the patient through prede ned randomized movement quadrants on the screen (Figure 1). e participants were encouraged to perform as big movement as possible, close to induction of more pain when necessary. To familiarize the participants with the test sequences, they performed 1 trial prior to the test, which data was not used in the analysis. Each patient then performed 6 trials in random order where each trial, measured the area the patient could cover within each of the four quarters, representing the outcome measure for each quarter (Figure 1). ere was a 3 second

pause between each trial but altogether 24 trials (4 quarters x 6 trials) were performed for each patient pre-post intervention, respectively.

e results were downloaded into a report immediately a er the test was completed and saved on the computer. A er the test, the patient received one mobilizing treatment session by an experienced physical therapist/manual therapist (EK), a er receiving information from the tester about which quarter was most restricted. Only this quarter was targeted in the treatment session. e duration of each treatment session, including a short history taken, was approximately 30-minute of mobilizing treatment to increase the restricted cervical movements focusing on that particular quarter. e mobilizing treatment included various modalities, such as so tissue mobilization e.g. "pump" massage and muscle energy techniques as well as various manual joint treatments, e.g. speci c joint mobilization, including high velocity, short amplitude thrust (manipulation). e manual therapist decided what mobilizing treatment suited each patient, i.e. pragmatic approach.

e participants were then re-tested immediately a er the mobilizing treatment to ascertain the e ect of the mobilizing treatment and to document its e ect.

Data Analysis

ere were no existing data on healthy individuals or pre-treatment versus post-treatment values of patients, which made it impossible to calculate the power of the study. Using trigonometry functions, the 3D angles were projected onto the two-dimensional screen as described when converting spherical coordinates into Cartesian coordinates. Flexion/extension and rotation angles were used to position the cursor in the plane. e raw data from x and y co-ordinates that the patient could cover in each quarter/quadrant was calculated as percentage increase from pre-intervention and post-intervention. e mean of 6 trials for each quarter was calculated and used for data analysis.

e pre-post di erences were analyzed using a paired t-test, with a single-tail analysis to increase the power of the test. e raw data was drawn from the database (Server) and the mean area covered by the patient in each of the 4 quarters selected for treatment was calculated by a custom-made so ware. Intraclass Correlation Coe cient, model 3.1 (single measures – mixed model) analyzed the intra-rater pre measurements in each quarter, respectively. Analyses were performed with the procedures implemented by Jamovi®-so ware (9th edition). Number, subjects, means and standard deviation (SD) were used for description of data. e signi cance level was set at $p<0.05$.

Results

Participants demographics

Twenty participants (9 males and 11 females) completed the CROM-Quarter test and were included in the analysis. e mean age of the participants was 33 years (± 10). Pain characteristics among participants at the time of visit for the mobilizing treatment are shown in Table 1.

CROM-Quarter test

e post treatment scores were signi cantly higher than the pre-treatment scores ($p<0.001$). (Figure 2). e mean of the participants' score for the x-y co-ordinates pre-treatment was 386 ± 130 (Table 2) (SEM 29.1) and post-treatment score was 794 ± 216 (Table 2) (SEM 48.3). e mean di erence for the x-y co-ordinates was 409 ± 143 (Table 2). e average overall improvement from baseline was 106% ± 38% (Table 2). e measurement on the quarters that were not treated

ID	Most restricted quarter	Pre	Post	Differences	Change in %
Subject 1	Upper right	397.9	1310.4	912.5	229.33%
Subject 2	Lower left	291	684.6	393.6	135.25%
Subject 3	Upper right	369.9	803.5	433.6	117.22%
Subject 4	Lower left	239.6	512.3	272.7	113.81%
Subject 5	Lower right	408.9	757.3	348.4	85.30%
Subject 6	Upper right	419.9	803.9	384	91.45%
Subject 7	Lower right	195.3	482.4	287.1	147%
Subject 8	Upper left	514	1069.4	555.4	108.05%
Subject 9	Lower left	263.6	571.9	308.3	116.96%
Subject 10	Upper left	436.1	905.9	469.8	107.73%
Subject 11	Lower right	301.2	608.5	307.3	102.03%
Subject 12	Lower left	344.2	734.9	390.7	113.51%
Subject 13	Upper right	550.7	961.6	410.9	74.61%
Subject 14	Upper right	365.3	819.8	454.5	124.42%
Subject 15	Lower right	191.1	510.8	319.7	167.29%
Subject 16	Upper left	585.8	1064.5	478.7	81.72%
Subject 17	Upper left	678.7	924.6	245.9	36.23%
Subject 18	Lower left	359.4	693.2	333.8	92.88%
Subject 19	Upper right	492.1	973.7	481.6	97.87%
Subject 20	Lower left	306.5	689.7	383.2	125.02%
Overall	Mean ± SD	386 ± 130	794 ± 216	409 ± 143	106% ± 38%

Table 2: Measurements of the most restricted quarters among all individual participants.

	Student's t				

Discussion

e purpose of this study was to examine if the CROM-Quarter test could be used pre- and post- intervention to document the e ects of a single mobilizing treatment session of the cervical spine in clinical practice. ere was a signi cant di erence between CROM-Quarter test measurements pre versus post–treatment ($p<0.001$) (Figure 2) with mean 106% ± 38% increase in the movements post- treatment (Table 2).

e results demonstrate that all participants showed improvement in range of motion a er the mobilizing treatment (Table 2). is indicates that the CROM-Quarter test can be used as a measurement tool a er a single mobilization treatment session. e measurements for the

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