นิพนธ์ต้นฉบับ ▪ Original Article

การตอบสนองของมุมการแอ่นของกระดูกสันหลังส่วนเอวและตัวแปรอื่นทางชีวกลศาสตร์ในผู้ที่มีภาวะกระดูกสันหลังส่วนเอวแอ่นมากกว่าปกติ: การศึกษาเชิงทดลอง

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Responsiveness of Lumbar Lordosis Angle and Other Biomechanical Parameters in Individuals with Lumbar Hyperlordosis: An Experimental Study

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หลักการและวัตถุประสงค์: การตรวจประเมินและการจัดการในผู้ที่มีภาวะกระดูกสันหลังส่วนเอวแอ่นมากกว่าปกติมีความสำคัญเพื่อป้องกันปัญหาทางกระดูกและกล้ามเนื้อในอนาคต การตอบสนองของตัวแปรจึงมีความสำคัญที่ควรทำการศึกษา เนื่องจากเป็นสิ่งที่แสดงความสามารถของแต่ละตัวแปรในการบ่งชี้การเปลี่ยนแปลงที่เกิดขึ้นต่างช่วงเวลาได้ ซึ่งยังไม่มีการศึกษาในปัจจุบัน วัตถุประสงค์ของงานวิจัยนี้ เพื่อดูการตอบสนองของตัวแปรทางชีวกลศาสตร์ในผู้ที่มีภาวะกระดูกสันหลังส่วนเอวแอ่นมากกว่าปกติ

วิธีการ: ผู้ที่มีกระดูกสันหลังส่วนเอวแอ่นมากกว่าปกติทั้งหมด 15 ราย มีอายุระหว่าง 20 ถึง 30 ปีได้รับการเชิญชวนเข้าทำการศึกษา ตัวแปรที่ใช้ในการประเมิน คือ องศาการแอ่นของกระดูกสันหลังส่วนเอว องศาการงอสะโพก องศาการกางสะโพก องศาการงอเข่า และร้อยละการหดตัวสูงสุดของ transversus abdominis/internal abdominal oblique, rectus abdominis, external abdominal oblique, lumbar erector spinae และ multifidus ผู้เข้าร่วมวิจัยจะได้รับการประเมิน 2 ครั้ง: ก่อนและหลังยืดกล้ามเนื้องอสะโพก

ผลการศึกษา: ค่าการเปลี่ยนแปลง ขนาดของผล และ standardized response mean (SRM) ได้รับการคำนวณเพื่อแสดงถึงค่าการตอบสนอง การศึกษานี้พบว่าตัวแปรที่มีการตอบสนองต่อการเปลี่ยนแปลงสูงสุดคือ องศาการแอ่นของกระดูกสันหลังส่วนเอว (ALL) โดยมีค่า standardized response mean (SRM) คือ 1.61 ขณะที่ตัวแปรอื่นมีการตอบสนองเพียงเล็กน้อย

Background and Objective: The assessment and management in individuals with lumbar hyperlordosis are important to prevent further musculoskeletal disorders. The responsiveness is necessary to be studied because it represents the ability of each parameter to indicate the change overtime, which awaits formal investigation. This study aimed to investigate the responsiveness of biomechanical parameters in individuals with lumbar hyperlordosis.

Methods: Fifteen individuals with lumbar hyperlordosis, aged 20 to 30 years, were recruited. The parameters measurement were angle of lumbar lordosis (ALL), degree of hip flexion, degree of hip abduction, degree of knee flexion, and percent maximum voluntary isometric contraction (%MVIC) of transversus abdominis/internal abdominal oblique (TrA/IO), rectus abdominis (RA), external abdominal oblique (EO), lumbar erector spine (LES), and multifidus (MF). They were assessed 2 times: before and after iliopsoas stretching.

Results: Change score, effect size, and standardized response mean (SRM) were calculated to represent the responsiveness of each parameter. The findings showed that the most responsive parameter was ALL, SRM of 1.61, while, the other parameters had lower

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สรุป: การศึกษาครั้งนี้สนับสนุนว่า องศาการแอ่นของกระดูกสันหลังส่วนเอว เป็นตัวแปรที่ตอบสนองต่อการเปลี่ยนแปลงสูงสุดในผู้ที่มีภาวะกระดูกสันหลังส่วนเอวแอ่นมากกว่าปกติภายหลังการรักษาเพื่อลดองศาการแอ่นของกระดูกสันหลังส่วนเอว

คำสำคัญ: คลื่นไฟฟ้ากล้ามเนื้อ, ขนาดของผล, ค่าการเปลี่ยนแปลง, กระดูกสันหลังส่วนเอว, ความไว

Conclusion: This study supported that ALL was the most responsive parameter to detect the change in individuals with lumbar hyperlordosis after the intervention aiming for decreasing lumbar lordosis.

Keywords: EMG, effect size, change score, lumbar spine, sensitivity

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Introduction

Lumbar hyperlordosis is an abnormal posture regarding the increase of lumbar lordosis which leads to compressive load to the posterior aspect of vertebral structures while the anterior aspect is stretched[1]. Abnormal loading on the lumbar spine can decrease the size of vertebral canal and intervertebral foramen which resulting in lumbar pathomechanics[1, 2]. Thus, the increasing of lumbar lordosis angle can be related to low back pain (LBP), spinal instability, spondylolisthesis, and stenosis[1, 3, 4]. The biomechanical relationships of lumbar hyperlordosis and shortened hip flexor muscles, weak abdominal and lumbar extensor muscles have been reported[1, 3, 5]. The shortening of hip flexor muscle, iliopsoas, is the primary cause of lumbar hyperlordosis[2, 6]. Thus, the stretching of iliopsoas with hold relax (HR) technique could significantly reduce the angle of lumbar lordosis (ALL)[7-10]. Abdominal muscles consist of transversus abdominis/internal abdominal oblique (TrA/IO), external abdominal oblique (EO) and rectus abdominis (RA). The function of TrA/IO and EO are important for stabilization lumbopelvic in sagittal plane. The TrA is the deepest abdominal muscle and co-contraction with the multifidus (MF). While, the RA is major muscle that controls pelvic tilt[11].Back muscle consist of lumbar erector spinae (LES), and MF. LES is superficial muscle that attach on thoracic and lumbar spine.

The responsiveness is the ability of parameters related to the changing of variables between before and after intervention, which is necessary for determination and consideration for efficacy of intervention. The recommended methods for statistical analysis to represent the responsiveness consist of change score, effect size and standardized response mean (SRM)[12].

Lumbar lordosis measurements can be done such as radiography image[1, 13], inclinometer [14], spinal mouse [13], and flexible ruler[13]. The flexible ruler is a clinically useful measurement for assessing the spinal posture. Several studies used this tool for measure the ALL[10, 15-17]. The reliability and validity of the flexible ruler found good correlation in intra-tester reliability (ICC = 0.97, N=89) and good validity when compared with radiography image for measuring ALL (r = 0.87) (17). Clinically, the modified Thomas test is the most common special test for identify hip and knee muscle length[18] with very good to excellent inter-rater reliability (ICC= 0.9 to 0.92) and test-retest (ICC = 0.63 to 0.75) reported[19]. Surface electromyography (sEMG) reported as percent maximum voluntary isometric contraction (%MVIC) represents muscle activation[20, 21]. Therefore, the responsiveness of each parameter is needed to be investigated since it is necessary for considering the efficacy of intervention. Therefore, this study aimed to examine the responsiveness of ALL, degrees of hip flexion, hip abduction and knee flexion, and percentage of MVIC of abdominal and back muscles in individuals with lumbar hyperlordosis.

Materials and Methods

Subjects

Fifteen individuals with hyperlordosis (7 females and 8 males) who have read and signed an informed consent were recruited. The inclusion criteria were age between 20 and 30 years, body mass index (BMI) ranged between 18.5 and 22.9 kg/m^2 [22], having ALL greater than 45.57 degrees for females and greater than 34.63 degrees for males [23], shortening of iliopsoas muscle was present at least on dominant side measured by modified Thomas test, hip flexion greater than 0 degree[24]. The exclusion criteria were back pain within the last 3 months, a history of abdominal and back surgery or fracture, red flags (infection, tumor, fracture, radicular syndrome, and inflammation), pregnancy or on menstruational period, having other

spinal deformities such as scoliosis, neurological, musculoskeletal or cardiopulmonary diseases. This study was approved by Mahidol University Central Institutional Review Board (MU-CIRB COA. NO. 2017/153.2808).

Measurements

All participants were assessed at pre-test and post-test after the interventions by the assessor. For ALL, each participant stood in normal anatomical position, the feet were equal to shoulder width and fixed eyes to the wall. The 50 cm flexible ruler placed from the spinous process of L1 to S2. The lumbar lordosis angle can be calculated by $\text{Ø}=4\arctan\frac{2H}{L}$; this formula based on Hart and Rose method [17, 23]. For muscle length, the modified Thomas test was used for assessing the length of hip flexor, hip abductor and knee extensor[18]. The researcher was blinded the scale of the goniometer during the measurement. For hip flexion, the axis is at the greater trochanter of femur. The stationary arm is the horizontal line parallel to the plinth in sagittal plane. The movable arm is at midline of the lateral aspect of the femur (Figure 1). For hip abduction, the axis is at the anterior superior iliac spine (ASIS). The stationary arm was placed on the tested thigh pointing to the axilla in frontal plane. The movable arm placed on the thigh pointing to the lateral aspect of the patella (Figure 2). For knee flexion, the axis is at lateral epicondyle of femur. The stationary arm was placed downward vertically. The movable arm was placed on the lateral aspect of the fibula (Figure 3). Another investigator recorded the measured angles[24].

The electromyography (EMG) was recorded using surface EMG (sEMG) (Telemyo 2400 G2, Receiver, Noraxon, USA) including 5 muscles; transversus abdominis/internal abdominal oblique (TrA/IO), rectus abdominis (RA), external abdominal oblique (EO), lumbar erector spine (LES) and multifidus (MF). All electrodes and a reference electrode were attached at the dominant side of the body and were suggested by The ABC of EMG[21, 25]. The targeted muscles were cleansed by sand paper and alcohol to decrease skin impedance of below 30 kΩ[21]. EMG system was set gain at 2,000 times; the raw data were filtered by Butterworth filter. Bandpass 30 to 350 Hz were used. The sampling frequency was set at 1,000 Hz[21]. The testing positions for the maximum voluntary isometric contraction (MVIC) of TrA/IO, RA, EO, LES

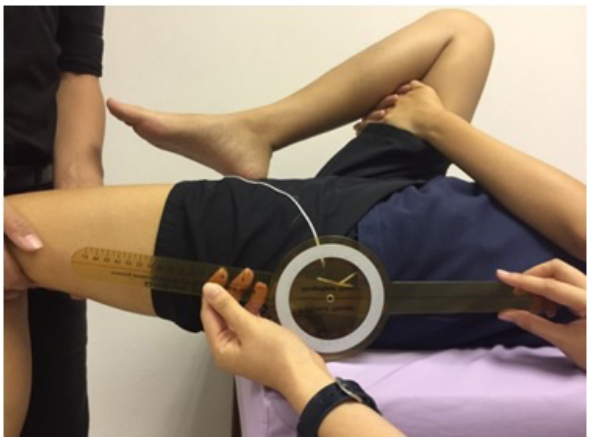

Figure 1 For hip flexion

Figure 2 For hip abduction

Figure 3 For knee flexion

and MF muscles were suggested by the EMG guideline. The muscle activation testing was in standing position for all muscles. So, participants stood in neutral position for 5 seconds. They were assessed three times, rested for 2 minutes between each time and the averaged data was calculated. Participants stood in usual standing position for 5 seconds and assessed three times. The muscle activation was calculated as %MVIC by the following equation[25]:

$$\%MVIC = \frac{(\text{Test EMG-Resting EMG})}{(\text{Max EMG-Resting EMG})} \times 100$$

This study has previously investigated the intra-tester reliability, $ICC_{(2,k)}$ in ALL, the length of hip flexor, hip abductor and knee extensor, and % MVIC of TrA/IO, EO, RA, LES and MF reported as 0.92, 0.85, 0.96, 0.96, 0.75, 0.94, 0.86, 0.99 and 0.97, respectively. The standard error of measurement (SEM) [26] was estimated as follows: $SEM = SD \times \sqrt{(1\text{-}ICC)}$

Interventions

All participants received hold-relax stretching for iliopsoas in modified Thomas position and move isometrically against manual resistance using a dynamometer with 20% of MVIC[27] hold 10 seconds and passively moved to the new range, 5 times at the dominant side and then another side (Figure 4).

Figure 4 The HR stretching on the iliopsoas muscle as the same position as modified Thomas test

Sample size

This study calculated sample size in accordance with the study by Malai et al., 2015[10]. The confidence interval was set at 95%, alpha level 5% and power 80%, with 20% extra for drop-outs. The sample size in this study is 12 participants in each group, and this study added 20% extra, therefore, they were 15 totally.

Statistical analysis

This study used the Statistical Package for Social Science (SPSS) version 23 (IBM Corp., Armonk, NY) for statistical analysis. The change score is the difference between pre-test and post-test (pre-test minus post-test). The effect size was the mean of change scores divided by standard deviation of the pre-test. According to Cohen's suggestion, ES value below 0.4 is considered small, 0.5 moderate, and 0.8 large. The standardized response mean (SRM) is the change score (pre-test minus post-test) divided by standard deviation of the change[28].

Results

Demographic and baseline data of the participants are shown in Table 1. The results of change scores and effect sizes are shown in Table 2. The change score of ALL was 5.12. The change score of degree hip flexion, hip abduction and knee flexion were 2.37, -0.34 and 0.24 degrees, respectively. The change score of MVIC of TrA/IO, EO, RA, LES and MF were -1.51, 0.04, 0.15, 0.18 and 0.13 respectively. The most responsiveness by effect size in this study was degree of hip flexion (effect size=0.89) and ALL (effect size=0.80). The SRM in this study, ALL was the most responsive (SRM=1.61).

Table 1 Demographic data and baseline data and of each variables

Characteristics and Parameters	Mean ± SD
Age (yr)	21.87±2.10
Weight (kg)	57.81±7.06
Height (cm)	166.8±6.10
BMI (kg/m^2)	20.7±1.37

SD = standard deviation; BMI = body mass index

Table 2 Change score, effect size and SRM of each parameter

Parameters	Pre-test mean±SD	Post-test mean±SD	Change score	SD (difference)	Effect size	SRM	SEM
ALL (degrees)	43.40±6.43	38.28±5.84	5.12	3.18	0.80	1.61	1.82
Degree of hip flexion (degrees)	6.71±2.67	4.34±2.01	2.37	1.67	0.89	1.42	1.03
Degree of hip abduction (degrees)	4.27±2.22	4.61±1.63	-0.34	1.64	-0.15	-0.21	0.44
Degree of knee flexion (degrees)	15.41±5.88	15.17±4.91	0.24	2.40	0.04	0.10	1.18
MVIC of TrA/IO (%)	9.17±5.06	10.69±7.54	-1.51	4.34	-0.30	-0.35	2.55
MVIC of EO (%)	2.08±1.80	2.04±1.65	0.04	0.86	0.02	0.04	0.44
MVIC of RA (%)	0.70±0.68	0.55±0.50	0.15	0.63	0.22	0.24	0.25
MVIC of LES (%)	1.32±1.92	1.13±1.66	0.18	0.60	0.10	0.31	0.11
MVIC of MF (%)	3.41±2.46	3.28±2.12	0.13	0.67	0.05	0.19	0.45

SD = standard deviation; SRM = standardized response mean; SEM = standard error of measurement
ALL = angle of lumbar lordosis; MVIC = maximum voluntary isometric contraction

Discussion

This study found that the most responsive parameters were the ALL, ES = 0.8, SRM=1.61, and the degree of hip flexion, ES = 0.89, SRM=1.42, to determine the change in individuals with lumbar hyperlordosis after stretching. According to Cohen's suggestion, those parameters were considered as large responsiveness. The other parameters were less responsive. The responsiveness of ALL and hip flexion angle in this study corresponded to the study conducted by Malai et al[10]. They determined the effect of hold relax on iliopsoas in chronic non-specific low back pain with lumbar hyperlordosis, they found the significant difference in changing ALL and degrees of hip flexion between pre-test and post-test. The previous study had higher change score than this study owing to the different approaches. Also, another study[29] found the immediate effect on reducing lumbar lordosis measured with ultrasonography, lumbar extension angle of L4 after decreased significantly. For muscle length, the most responsiveness is degree of hip flexion because all participants in this study received the stretching on hip flexor directly. This study used the intensity of 20% MVIC according to the suggestion of Feland and Marin[27]. The stretching was done in modified Thomas test position[24]. Anyhow, the stretching went to only hip flexor, while hip abductor and knee extensor were not done. The result therefore revealed the specificity of the stretching. For EMG result, it seemed to be less responsive. It was due to the measurement done in standing position which the muscle activation of abdominal and back muscles needed in little percentage which can be difficult to observe its change. Anyhow, the future study should investigate muscle activation in other positions or actions with more exertion needed to sufficiently detect the change after the interventions. The limitation of this study was the subjects in this study were young healthy adults with lumbar hyperlordosis which cannot be generalized to other age groups.

Conclusion

This study examined the responsiveness of the parameters in individuals with lumbar hyperlordosis after HR stretching on the iliopsoas muscle. The most responsiveness after the intervention went to ALL and degree of hip flexion, while other parameters were less responsive.

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