ORIGINAL ARTICLE

Nr 2022;12 (4):621-627

The Effects of Lower Crossed Syndrome on Upper Body Posture during Sitting in Female Office Workers

P. Puagprakong[1], A. Kanjanasilanont[1], K. Sornkaew[2], W. S. Brady[3]

[1] *Department of Rehabilitation Science and Movement, Faculty of Sports Science, Kasetsart University, Nakhon Pathom, Thailand*
[2] *Department of Physical Therapy, Faculty of Allied Health Sciences, Naresuan University, Phitsanulok, Thailand*
[3] *Department of Health and Sport Science, Faculty of Education, Mahasarakham University, Mahasarakham, Thailand*

CORRESPONDING AUTHOR:
Aris Kanjanasilanont
Department of Rehabilitation Science and Movement
Faculty of Sports Science
Kasetsart University
Malaiman Road
Nakhon Pathom
73410 Thailand
E-mail: aris.k@ku.th

DOI:
10.32098/mltj.04.2022.19

LEVEL OF EVIDENCE: 2

SUMMARY

Background. Office workers often have musculoskeletal disorders (MSDs) such as back pain, neck pain, and shoulder pain. Muscular imbalance is a risk factor associated with MSDs. Lower crossed syndrome (LCS) is also referred to as muscle imbalance of the lower extremity and caused by tightness and weakness of muscles in the lumbopelvic area, which affects the normal movement patterns of sitting position. It leads to low back pain and might affect upper body posture differently.This research investigated the effects of lower crossed syndrome on a craniovertebral angle, sagittal shoulder angle, and trunk flexion angle during sitting in female office workers.
Methods. Forty-eight office workers (healthy:18, LCS type A:18, LCS type B:18) who work in computer use for at least 4 hours/day, office work experience at least five years were recruited. Testing posture was a sitting at computer workstation that adjust to each participant. One picture was taken from the lateral view during sitting. One-way ANOVA and *post-hoc* Turkey test were used to analyze the data.
Results. The people with lower crossed syndrome type B have less craniovertebral angles, sagittal shoulder angles, and trunk flexion angle than healthy people and people with lower crossed syndrome type A significantly during sitting.
Conclusions. Different types of the lower crossed syndrome affect upper body posture during sitting position differently. The muscle imbalance contributes bad posture which may lead to MSDs.

KEY WORDS
Lower crossed syndrome; muscle imbalance; upper body postures; sitting position; office workers.

INTRODUCTION

Office workers are usually required to sit for long hours working on a computer while spending most of their time in a sitting position (1-3). Occupational group often have health problems associated with musculoskeletal disorders (MSDs) such as back pain, neck pain, shoulder pain, and upper limb pain are common in office workers (4-6). The potential factors of MSDs are gender, age (7, 8), number of working hours per day, and working postures especially sitting posture (8, 9). In sitting posture, there is an alteration occurred at hip joint, lumbar, thoracic and cervical spine as well as muscle adaptation (10).

Another potential risk factor for MSDs is muscle imbalance (11, 12). Based on Janda's conceptual knowledge it has been reported that key components of muscle imbalance include muscle tightness and weakness. In 1987, Janda (13) had identified the lower crossed syndrome (LCS) is also referred to as pelvic crossed syndrome (PXS) (14). There are two subtypes of LCS including type A and B. Muscle imbalance in LCS type A (posterior pelvic crossed syndrome - PPXS) occurs due to the tightness of the hip flexors and low back extensors muscle combined with the weakness of the abdominal wall and gluteal muscles, which lead to excessive anterior pelvic tilt and increased lumbar lordosis. In contrast, muscle imbalance in LCS type B (anterior pelvic crossed syndrome - APXS) occurs due to the tightness of the hip extensors (hamstrings and piriformis) and upper abdominal muscle combined with the weakness of lower abdominals, deep hip flexors, and low back extensors, which lead to increased posterior rotation of the pelvis and decreased lumbar lordosis (15). Previous studies have shown that LCS is caused by tightness and weakness of muscles in the lumbo-pelvic area. The rotation of the pelvis causes an increased or decreased curve of the lumbar spine and related with the low back pain (LBP) (16). Nadler *et al*. (17) found hip extensor strength imbalance is associated with the occurrence of LBP in female athletes. Arab *et al*. (12) has reported that muscle imbalance of hip extensor weakness and back extensor tightness could increase the risk of LBP. Also, hip extensors strength has a correlation with back extensors length in people with LBP. Ruas and Viera (11) found muscle strength imbalances and/or flexibility of hips, spine, and trunk. Especially, the lumbo-pelvic-hip complex results in a decrease in the ability to control body balance and postural stability in people with LBP (18). Lumbo-pelvic complex coordination in a sitting position and the risk of low back pain have been described. According to a recent review, LCS affects the normal movement patterns of the lumbo-pelvic that affect the center of the body while sitting (19). Changes in the pelvis are associated with the lumbo-pelvic complex function, resulting in changing of posture and movement of the body (14, 15). It might lead to abnormalities in the upper body, due to the lumbopelvic-hip structure is a direct connection between both lower extremities and the upper extremities of the body (20). There is no study to reveal the effect of the different types of LCS on upper body posture during sitting position. Thus, the objective of this study was to investigate the effects of lower cross syndrome on craniovertebral angle, sagittal shoulder angle and trunk flexion angle during sitting in female office workers.

MATERIALS AND METHODS

Participants

Convenience office workers in the university in Bangkok and metropolitans were invited into the study. An invitation letter with information sheets were sent to the office workers, and a consent form was signed before starting the study. Inclusion criteria includes female office workers aged between 30-45 years, worked in a computer use at least 4 hours/day (21), office work experience at least five years (22), had been examined and diagnosed by an ophthalmologist to see if the sight is normal or if their eyeglasses are appropriate for their eyesight, a body mass index (BMI) between 18.0-29.9 kg/m^2, and right-hand dominant were recruited. Those who had neurological disorders, pregnancy, or history of the spine, hip, or lower limb surgery or musculoskeletal problem in one month previously were excluded. All participants were evaluated by an expert physical therapist, who has 10 experiences in MSD filed. The general information was gathered and physical examination were performed on the following measurements: 1) standing posture assessment in frontal and lateral view, 2) muscle length testing (iliopsoas length was assessed by using the Thomas test (23), rectus femoris length was assessed using the modified Thomas test (24), hamstrings length was assessed using the straight leg raise (SLR) (25), thoracolumbar and lumbar extensors muscle were assessed using an inclinometer (26)), and 3) muscle power testing gluteus maximus, gluteus medius (27), abdominal muscle, hip flexors muscle and back extensors muscle using a wireless muscle tester (Echo wireless muscle tester, Jtech, USA) (28). Participants were divided into three groups: healthy group (n = 18), LCS type A (n = 18), and LCS type B (n = 18). The LCS type A, participants were classified if they had the tightness of the iliopsoas, rectus femoris, and thoracolumbar extensors muscles, combined with the weakness of the gluteus medius and maximus, and abdominal muscles. While the LCS type B, participants were classified if they had the tightness of the hamstrings, combined with the weakness of the abdominal muscle, hip flexors, and back extensors muscles (15).

Instrumentation (2-D motion analysis)

The upper body postures

Head postures (head tilt and craniovertebral angle), shoulder posture (sagittal shoulder angle) and trunk posture (trunk flexion angle) of each participant was videotaped by using a single video camera during a performed task in sitting postures. Six reflective markers were placed on the external canthus of eye, the tragus of ear, the acromion, the spinous process of the seventh cervical vertebra (C7), the spinous process of the first lumbar vertebra (L1), and the midpoint of the greater trochanter (G.T.). All markers were attached on the right side of each participant's bodies by using double-sided tape (29-32). Images were obtained at a sampling rate of 30 Hz for digitalization. The camera was placed in the horizontal level 2 meters from the participants and fixed on a tripod to reduce expected lens errors and minimize parallax errors. The center of the lens was set at the participant's spinous process of the C7.

Experimental procedure

Participants were seated on a chair without backrest that can adjust the height. The seat position was set at participants' flexed hips and knees joint at 90 degrees whilst both feet were fully contacted on the floor. One picture of this posture was taken from the lateral view.

The head tilt angle was defined as the relative angle formed by the horizontal line drawn through the right tragus of ear marker and the line joining the right tragus of ear with the external canthus of eye markers (32). The craniovertebral angle was defined as the relative angle formed by the horizontal line drawn through the C7 marker and the line joining the C7 with the right tragus of the ear markers (29, 32). The sagittal shoulder angle was defined as the relative angle formed by the horizontal line and the line joining the C7 and the right acromion markers (31). The trunk flexion angle was defined as the relative angle between 2 lines extending from the right acromion to the L1 markers and the L1 to the right GT markers (30) (**figure 1**).

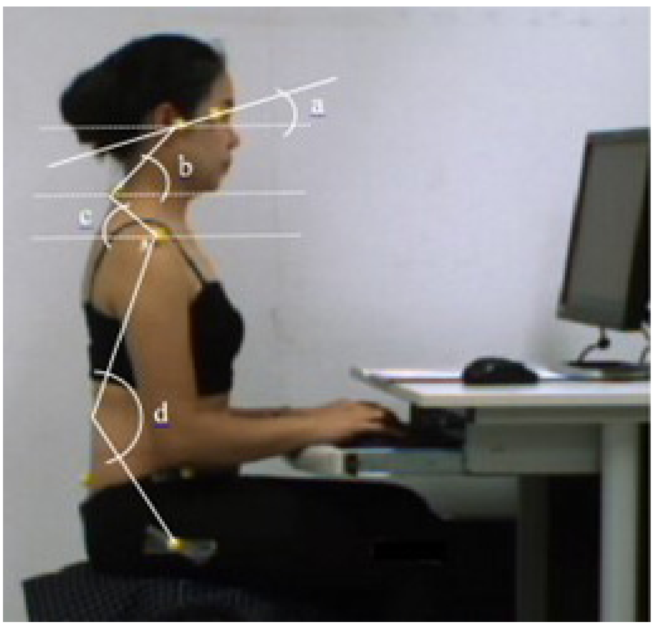

Figure 1. The postural angles.

(a) Head tilt angle; **(b)** Craniovertebral angle; **(c)** Sagittal shoulder angle; **(d)** Trunk flexion angle.

Statistical analysis

Participant characteristics were presented by descriptive statistic. Head tilt angle and craniovertebral angle, sagittal shoulder angle and trunk flexion angle were tested for normal distribution. If data were normal distributed, the one-way analysis of variance (ANOVA) was used to compare differences between groups. If data were not normal distributed, the Kruskal-Wallis one-way analysis of variance (ANOVA) was used to compare differences between groups. Post-hoc analysis was performed with the Turkey test. The level of significance was set at 0.05 for all statistical analyses.

Ethics statement

This research was approved by the Kasetsart University Human Research Ethics committee (KUREC-HS63/013 – Date of approval: August 31, 2020).

RESULTS

Characteristics of participants

The information about general characteristics, including age, weight, height, body mass index, working year and computer use time/day, as shown in **table I**.

Upper body postures

Head postures (craniovertebral and head tilt angle)

When compared among 3 groups (**figure 2**), there were no significant differences in head tilt angle among the three groups. But the craniovertebral angle in the LCS type B group significantly decreased compared with a healthy group ($p < 0.05$).

Table I. General characteristics of participants (n = 54).

Characteristic	Healthy mean (SD)	LCS type mean (SD)	LCS type B mean (SD)
Age (years)	37.59 (4.15)	37.75 (4.30)	38.02 (3.74)
Weight (kg)	54.67 (9.27)	55.22 (8.95)	55.72 (9.51)
Height (cm)	158.50 (3.11)	158.39 (4.17)	160.94 (6.13)
BMI (kg/m²)	21.74 (3.49)	21.99 (3.35)	21.45 (3.05)
Working year (years)	9.82 (4.72)	9.98 (4.28)	10.05 (4.65)
Computer use time/day (h)	6.67 (0.84)	6.42 (0.84)	6.39 (0.61)

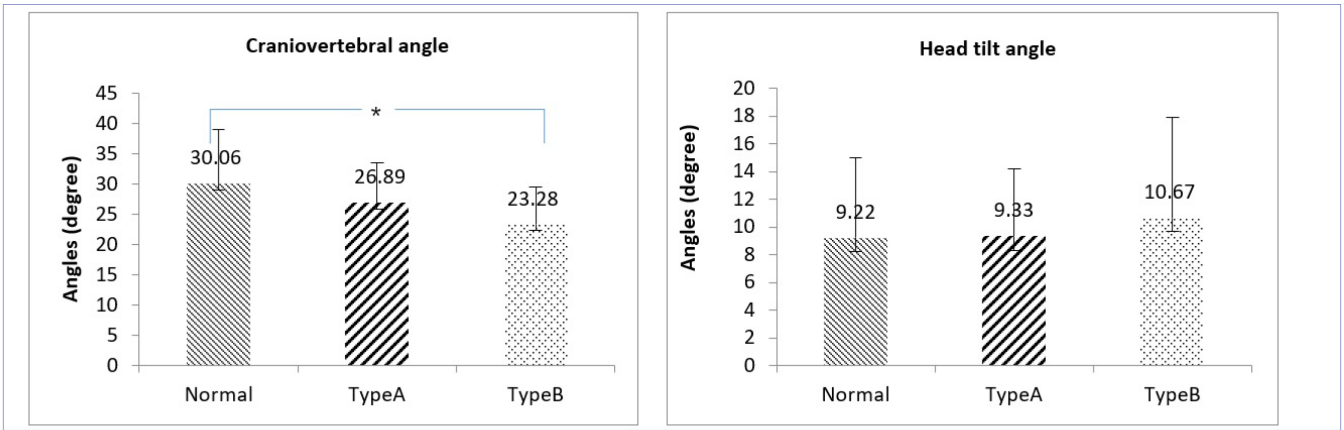

Figure 2. Comparison of craniovertebral and head tilt angles between groups.
*p < 0.05.

Shoulder posture (sagittal shoulder angle) and trunk posture (trunk flexion angle)

When compared among 3 groups (**figure 3**), the sagittal shoulder angle in the LCS type B group significantly decreased more than healthy and LCS type A group ($p < 0.05$, $p < 0.01$, respectively). While the trunk flexion angle in the LCS type B group significantly decreased more than LCS type A and healthy group ($p < 0.01$, $p < 0.05$, respectively).

DISCUSSION

In this study, found that people with the LCS type B had significant differences of upper body postures while sitting compared with healthy and those with the LCS type A, in the craniovertebral angle, sagittal shoulder angle, and trunk flexion. People with lower LCS type B showed a significant reduction of craniovertebral angles and sagittal shoulder angles compared with healthy group, and people with LCS type A. This might be due to a tightness of the hamstrings muscles among people with LCS type B causes the pelvis to shift anteriorly with posterior tilt resulting in decreased lumbar lordosis and causing thoracic spine compensation, by increasing kyphosis curve (16). Additionally, the reduction in lumbar lordosis was associated with increasing lordotic curve of cervical spine (33). Caneiro *et al.* (34) reported that slump sitting produced changing curve of the thoracic and cervical spines, was associated with forward head which upper cervical spines showed an increased extension angle and lower cervical spines showed a decreased extension angle. Some studies showed the association between head position and shoulder posture (29, 33, 35-37). Haddadi *et al.* (38) also reported that a slump sitting position may be associated with reduced extensor muscle endurance in nonspecific chronic low back pain (38) so interestingly, the future study needs to investigate the effect of the LCS type

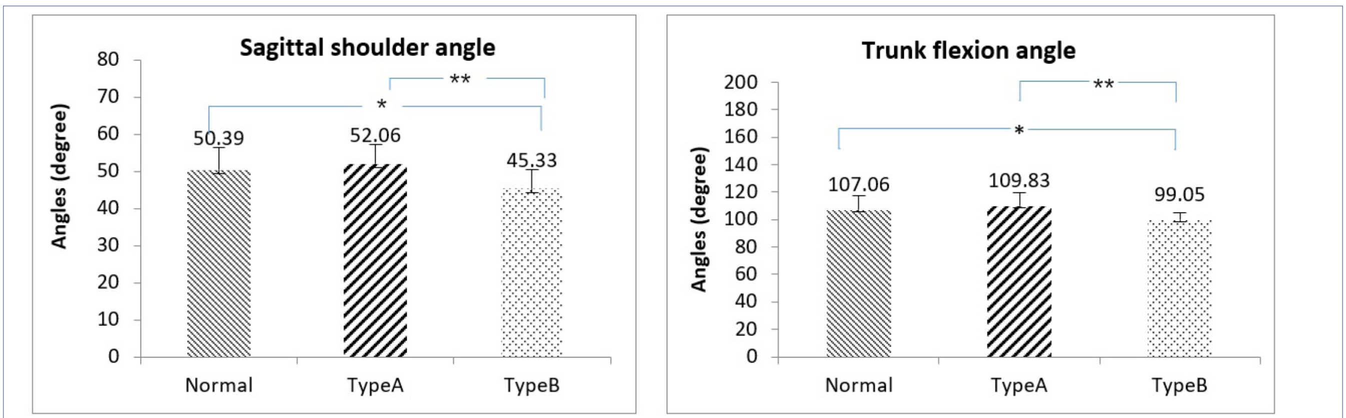

Figure 3. Comparison of sagittal shoulder and trunk flexion angles between groups.
*p < 0.05; * p < 0.01

B with nonspecific chronic low back pain on upper body postures while sitting.

For trunk flexion angle, this study found that people with the LCS type B had less trunk flexion angle than healthy people and those with LCS type A significantly, possibly due to tightness of the upper abdominal muscles, as well as greater stretching of back extensor muscles results in kyphosis of thoracic spine and a decrease in lumbar lordosis, so, people with the LCS type B had bending posture more than healthy groups and people with LCS type A (14, 15). According to Singla and Veqar (39) found that the thoracic spine increased kyphosis due to the tightness of the anterior longitudinal ligaments and upper abdominal muscles, while the extensor muscles and posterior ligaments of the dorsal spine were stretched. Caneiro *et al*. (34) showed that increased thoracic flexion results in an anterior translation of the head and neck flexion, which Janda (13) said that people with LCS type B use muscles to compensate movements in a thoracic kyphosis and head forward (14). Forward head posture (FHP) is one of the most prevalent abnormal postures and linked with many musculoskeletal dysfunction such as shoulder pain, neck pain. The previous study revealed that thickness change of Longus colli (LCo) muscle between resting and contraction state was significantly smaller in women with forward head posture compared with control group which this muscle is important in controlling cervical lordosis and maintaining normal posture of the cervical spine (40). Furthermore, Singla and Veqar (39) reported that thoracic kyphosis increased resulting in decreased movement of glenohumeral joints.

Accordingly, the theory and principle of biomechanical of lumbar spine and pelvic rhythm, since the pelvic floor is structured next to the sacrum and the upper of sacrum bone attached to the lumbar spine and the lower part is attached to coccyx bone, which likes chain. So, if the posture of sitting changes, it affects the movement of the pelvis and lumbar spine, chest and neck. When the pelvis rotates to the back, either in a standing position or sitting. The tip of the coccyx moves downwards and comes in front. The center of gravity falls above or behind the position of ischial tuberosity on both sides result in the back to be flattened or the lumbar spine more bent. The thoracic and cervical spines form compensatory movements so that the balanced body can stabilize in a standing or sitting position by increasing the arc of the thoracic and lower cervical spines. Notice from both shoulders wrapped to the front. The extensor muscles of neck are more contracted, the upper cervical spine is more concave to maintain balance, causing the head to protrude out front (41, 42). Thus, if the joints or muscles of the lower part are abnormal, they may also affect the movement of the upper part as well. This study used tightness of muscles and muscle strength tests to identify imbalances, in which people with LCS type B had short contractions of hip extensors muscles and upper abdominal muscles. In combination with the weakness of the lower abdominal muscles, the deep hip flexors muscles and the back extensors muscles, which may cause the participates to not properly control their sitting position. In contrast, good sitting posture produces center gravity on ischial tuberosity on both sides and the lumbar spine has a normal lordotic curve (10).

However, this study has some limitations. First, it did not evaluate muscle activation while sitting using electromyography (EMG), so it was not possible to clearly determine the alteration of muscle activity during sitting. Second, participants were seated on a chair without backrest which it is not type of chair that they use normally. In the office also has different types of chairs and tables for working. Third, this study investigated in only female office workers. Third, the participants were not interviewed the muscle pain or discomfort feeling during the test with sitting posture. In the future, there still need study more in this area, which may be useful for the prevention and treatment of abnormalities caused by sitting posture.

CONCLUSIONS

Different types of the lower crossed syndrome (LCS) affect upper body posture during sitting position differently. The muscle imbalance contributes bad posture in the sitting position. It might lead to musculoskeletal disorders. So, the office workers should promote their muscle balance. It may assist with good posture.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

PP: study design, data collection, data analysis, manuscript writing and revision. AK: study design, data collection, data analysis, statistical analysis, manuscript writing and revision. KS, WSB: manuscript reviewing and revision. All authors read and approved the final version of the manuscript.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. Thorp AA, Healy GN, Winkler E, et al. Prolonged sedentary time and physical activity in workplace and non-work contexts: a cross-sectional study of office, customer service and call centre employees. Int J Behav Nutr Phys Act 2012;9:128.
2. Clemes SA, O'Connell SE, Edwardson CL. Office workers objectively measured sedentary behavior and physical activity during and outside working hours. J Occup Environ Med 2014;56(3):298-303.
3. Ryan CG, Dall PM, Granat MH, Grant PM. Sitting patterns at work: objective measurement of adherence to current recommendations. Ergonomics 2011;54(6):531-8.
4. Healy G, Lawler S, Thorp A, Neuhaus M, Robson E, Owen N, Dunstan, D. Reducing prolonged sitting in the workplace (an evidence review: full report). Melbourne, Australia: Victorian Health Promotion Foundation, 2012. Available at: https://www.vichealth.vic.gov.au/~/media/resourcecentre/publicationsandresources/economic%20participation/2012%20workplace/chw_sitting_full_web_final.ashx.
5. Parry S, Straker L. The contribution of office work to sedentary behaviour associated risk. BMC Public Health 2013;13(1):296.
6. Hadgraft NT, Healy GN, Owen N, et al. Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations. Prev Med Rep 2016;4:184-91.
7. Cagnie B, Danneels L, Van Tiggelen D, De Loose V, Cambier, D. Individual and work-related risk factors for neck pain among office workers: a cross sectional study. Eur Spine J 2007;16(5):679-86.
8. Spyropoulos P, Papathanasiou G, Georgoudis G, Chronopoulos E, Koutis H, Koumoutsou F. Prevalence of low back pain in greek public office workers. Pain Physician 2007;10(5):651-9.
9. Waongenngarm P, Rajaratnam BS, Janwantanakul P. Perceived body discomfort and trunk muscle activity in three prolonged sitting postures. J Phys Ther Sci 2015;27(7):2183-7.
10. Harrison DD, Harrison SO, Croft AC, Harrison DE, Troyanovich SJ. Sitting biomechanics part I: review of the literature. J Manipulative Physiol Ther 1999;22(9):594-609.
11. Ruas CV, Viera, A. Do muscle strength imbalances and low flexibility levels lead to low back pain? a brief review. J Funct Morphol Kinesiol 2017;2(3):29.
12. Arab AM, Soleimanifar M, Nourbakhsh MR. Relationship Between Hip Extensor Strength and Back Extensor Length in Patients With Low Back Pain: A Cross-Sectional Study. J Manipulative Physiol Ther 2019;42(2):125-31.
13. Janda, V. Muscles and motor control in low back pain: assessment and management. In: Twomey LT (ed). Physical therapy of the low back. New York: Churchill Livingstone, 1987: pp 253-78.
14. Page P, Frank CC, Lardner R. Assessment and treatment of muscle imbalance: The Janda approach. Windsor, United States of America: Human Kinetics, 2010.
15. Key J, Clift A, Condie F, Harley C. A model of movement dysfunction provides a classification system guiding diagnosis and therapeutic care in spinal pain and related musculoskeletal syndromes: a paradigm shift-Part 2. J Bodyw Mov Ther. 2008 Apr;12(2):105-20.
16. Neumann D.A. Kinesiology of the musculoskeletal system: foundations for physical rehabilitation (1st edition). Missouri: Mosby, 2017.
17. Nadler SF, Malanga GA, Feinberg JH, Prybicien M, Stitik TP, DePrince M. Relationship between hip muscle imbalance and occurrence of low back pain in collegiate athletes: a prospective study. Am J Phys Med Rehabil 2001;80(8):572-7.
18. Carpes FP, Reinehr FB, Mota CB. Effects of a program for trunk strength and stability on pain, low back and pelvis kinematics, and body balance: a pilot study. J Bodyw Mov Ther 2008;12(1):22-30.
19. Zemp R, Fliesser M, Wippert PM, Taylor WR, Lorenzetti S. Occupational sitting behaviour and its relationship with back pain - A pilot study. Appl Ergon 2016;56:84-91.
20. Powers CM. The influence of altered lower-extremity kinematics on patellofemoral joint dysfunction: a theoretical perspective. J Orthop Sports Phys Ther 2003;33(11):639-46.
21. Szeto GP, Straker L, Raine S. A field comparison of neck and shoulder postures in symptomatic and asymptomatic office workers. Appl Ergon 2002;33(1):75-84.
22. D'Souza JC, Werner RA, Keyserling WM, et al. Analysis of the Third National Health and Nutrition Examination Survey (NHANES III) using expert ratings of job categories. Am J Ind Med 2008;51(1):37-46.
23. Peeler JD, Andersson, JE. Reliability of the Thomas test for assessing range of motion about the hip. J Phys Ther Sport 2007;8(1):14-21.
24. Peeler JD, Andersson JE. Reliability limits of the modified Thomas test for assessing rectus femoris muscle flexibility about the knee joint. J Athl Train 2008;43(5):470-6.
25. Miyamoto N, Hirata K, Kimura N, Miyamoto-Mikami E. Contributions of Hamstring Stiffness to Straight-Leg-Raise and Sit-and-Reach Test Scores. Int J Sports Med 2018;39(2):110-4.
26. Laudner K, Lynall R, Williams JG, Wong R, Onuki T, Meister K. Thoracolumbar range of motion in baseball pitchers and position players. Int J Sports Phys Ther 2013;8(6):777-83.
27. Krause DA, Neuger MD, Lambert KA, Johnson AE, DeVinny HA, Hollman JH. Effects of examiner strength on reliability of hip-strength testing using a handheld dynamometer. J Sport Rehabil 2014;23(1):56-64.
28. De Blaiser C, De Ridder R, Willems T, Danneels L, Roosen P. Reliability and validity of trunk flexor and trunk extensor strength measurements using handheld dynamometry in a healthy athletic population. Phys Ther Sport 2018;34:180-6.
29. Lau KT, Cheung KY, Chan KB, Chan MH, Lo KY, Chiu TT. Relationships between sagittal postures of thoracic and cervical spine, presence of neck pain, neck pain severity and disability. Man Ther 2010;15(5):457-62.
30. Lee JH, Park SY, Yoo WG. Changes in craniocervical and trunk flexion angles and gluteal pressure during VDT work with continuous cross-legged sitting. J Occup Health 2011;53(5):350-5.

31. Mo SW, Xu DQ, Li JX, Liu M. Effect of backpack load on the head, cervical spine and shoulder postures in children during gait termination. Ergonomics 2013;56(12):1908-16.
32. Salahzadeh Z, Maroufi N, Ahmadi A, et al. Assessment of forward head posture in females: observational and photogrammetry methods. J Back Musculoskelet Rehabil 2014;27(2):131-9.
33. Quek J, Pua YH, Clark RA, Bryant AL. Effects of thoracic kyphosis and forward head posture on cervical range of motion in older adults. Man Ther 2013;18(1):65-71.
34. Caneiro JP, O'Sullivan P, Burnett A, et al. The influence of different sitting postures on head/neck posture and muscle activity. Man Ther 2010;15(1):54-60.
35. Thigpen CA, Padua DA, Michener LA, et al. Head and shoulder posture affect scapular mechanics and muscle activity in overhead tasks. J Electromyogr Kinesiol 2010;20(4):701-9.
36. Lee JH, Cynn HS, Yi CH, Kwon OY, Yoon TL. Predictor variables for forward scapular posture including posterior shoulder tightness. J Bodyw Mov Ther 2015;19(2):253-60.
37. Kwon JW, Son SM, Lee NK. Changes in upper-extremity muscle activities due to head position in subjects with a forward head posture and rounded shoulders. J Phys Ther Sci 2015;27(6):1739-42.
38. Haddadi Esfahani N, Dommerholt J, Sadat Rezaeian Z. Core muscles endurance in sedentary staffs with and without nonspecific chronic low back: A cross-sectional study. Muscles Ligaments Tendons J 2021;11(1):136-50.
39. Singla D, Veqar Z. Association Between Forward Head, Rounded Shoulders, and Increased Thoracic Kyphosis: A Review of the Literature. J Chiropr Med 2017;16(3):220-9.
40. Bokaee F, Dehghan Manshadi F. Performance of longus colli muscle in women with and without forward head posture. Muscles Ligaments Tendons J 2021;11(1):193-200.
41. O'Sullivan PB, Mitchell T, Bulich P, Waller R, Holte J. The relationship beween posture and back muscle endurance in industrial workers with flexion-related low back pain. Man Ther 2006;11(4):264-71.
42. O'Leary T, Sterling, J. Structure and function of the cervical region. In: Whiplash, headache, and neck pain: research-based directions for physical therapies. Edinburgh: Churchill Livingstone, 2008: p. 31.