The Effects of Postural Education or Corrective Exercise Intervention on the Craniovertebral Angle in Young Adults with Forward Head Posture: A Randomized Controlled Trial

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Study Protocol, Statistical Analysis, and Results

Study Protocol

Participants who responded to invitations to voluntarily participate completed the Physical Activity Readiness Questionnaire (PAR-Q+) (Warburton et al. 2011), followed by a questionnaire to rate their current stage of change (SOC) from the Transtheoretical Model adapted to assess exercise/postural modification behavior change. On this questionnaire, participants also responded to a yes/no question regarding if they have had a recent injury to their head, shoulders, or spine; or have ever been diagnosed with a pathology related to their cervical/thoracic spine or extremities, as part of exclusion criteria for the study. Participants then underwent a head posture screening with the use of photogrammetry. Screening was performed by the primary investigator who is a licensed physical therapist in the Liberty University Biomechanics & Motion Analysis Laboratory.

Participants were asked to arrive at the lab wearing either a tank top or t-shirt, as well as to have their hair tied back if necessary. Height and weight were measured using a digital scale (Health-o-meter Professional, model 500KL, McCook, IL). Participants were instructed to sit comfortably on a stool with hands resting approximately two-thirds down their thighs with palms supinated and feet flat on the ground with hips and knees at 90 degrees (Richards et al. 2016); and to look straight ahead at an opposite wall in the laboratory (Kim et al. 2016). A digital camera (Canon Powershot, model SX540, Tokyo, Japan) was mounted and leveled on a tripod (Manfrotto, model 055, Cassola, IT) and placed three meters away from the subject (Ruivo et al. 2014). Two photographs were taken of participant's posture (Kim et al. 2016). Immediately after data capture, image files were uploaded into Kinovea video analysis software (version 8.15) for CVA assessment. On each image file, the PI assessed participant CVA by measuring the angle

between the intersection of two lines: the first line drawn from the tragus of the ear to the spinous process of C7 vertebrae and the second line drawn horizontally through C7 spinous process (Kim et al. 2016). A second researcher directly observed the PI perform each CVA assessment, as well as provided verbal agreement with the accuracy of angle measurement. For each participant, the CVA was derived by taking the mean of two CVA measurements that were assessed on the captured photographs (Kim et al. 2016).

Inclusion criteria included completion of informed consent, craniovertebral angle ≤ 53 degrees (Lee et al. 2017) and self-rating of Transtheoretical Model stage of change stage ≥ 3/5 on a questionnaire to indicate their readiness to comply with an assigned exercise prescription or postural guidelines (Kuroda et al. 2012). Exclusion criteria consisted of any musculoskeletal injury to the head, shoulders, or spine within the last six months; diagnosis of pathology related to the cervical spine, thoracic spine, or upper extremities; or non-clearance for physical activity based on results of the PAR-Q+ questionnaire. A total of 79 participants met inclusion criteria and were included in the study.

Randomization of participant group assignments was completed by the PI using a block randomization generator on a website (http://www.randomization.com). Utilizing a sequence created by the block randomizer, the PI placed participants who met inclusion criteria into one of four groups: (PE; n = 20), self-myofascial release + stretching (SMRS; n = 20), self-myofascial release + stretching + strengthening (SMRSS; n = 19), and control group (CG; n = 20). A hard-copy of the sequence generator report was kept concealed in a manila folder and was only opened by the PI during group delegation. Participants and researchers were not blinded to group assignment.

Intervention Groups

Postural Education (PE) Group. Immediately after baseline posture assessment, PE group members received a one-time 20-minute in-person one-on-one standardized educational session by a research team member in the laboratory. Topics included health risks associated with forward head posture (Bayattork et al. 2019; Cuellar & Lanman 2017; Kalichman et al. 2016; Hansraj 2014; Lau et al. 2010); postural guidelines for using mobile electronic devices (Abdelhameed & Abdel-aziem 2016; Gustaffson 2012; Syamala et al. 2018), desktop computers (NIH 2021), laptop computers (NIH 2021; Sahu et al. 2021), and rest break guidelines (Kim & Koo 2016; Neupane et al. 2017; Vate-U-Lan 2015; Kar & Hedge 2020; Carter et al. 2018; Engelmann et al. 2011). At the conclusion of the educational session, each PE group participant was emailed a copy of the presented educational information and guidelines. A weekly email was sent to group members during the 4-week intervention period to provide reminders and encouragement to adhere to postural guidelines. Participants were asked not to begin any new exercise program or alter their current physical activity level over the next four weeks.

Self-Myofascial Release + Stretching (SMRS) Group. Immediately after baseline posture assessment, SMRS group members received a 15-minute in-person one-on-one standardized instructional/training session for the SMRS intervention provided by a research team member in the laboratory. A 12 x 6 x 6 inch high-density myofascial roller (NASM Tool, Cygnet Systems, Dallas, TX) and a 23-inch soft-tissue mobilization tool (STMT) (Therapist's Choice® Pressure Point Hook Cane, Tampa, FL) was provided at no cost to group members to enable implementation of a 4-week home program. Implemented protocols followed the National Academy of Sports Medicine (NASM) recommendations for inhibitory and lengthening techniques (Fahmy 2022). Participants were instructed to apply self-myofascial release (SMR) to the thoracic spine (TS) using the myofascial roller by holding pressure over the central region of

the TS for 30 seconds, followed by six repetitions of active rolling up and down the length of the TS (up + down equaling 1 repetition) over a 90 second time period to promote mobilization of restricted myofascial tissues and restoration of upright posture (Fahmy 2022). Participants were asked to apply SMR to the center of the muscle belly in bilateral sternocleidomastoid (SCM) and upper cervical extensor (UCE) muscles using self-applied pressure with fingertips, while the STMT was utilized to administer SMR to center of the muscle belly in bilateral upper trapezius (UT) muscle and pectoralis minor (PM) muscle for 30 seconds (Fahmy 2022). For the first two weeks of the study, participants performed SMR three times per week on non-consecutive days. During weeks three and four, participants were instructed to progress SMR protocol frequency to five days per week. They were also instructed to perform static stretching to bilateral SCM, UT, PM, and UCE muscles after SMR on three non-consecutive days per week. During the first two weeks of the study, subjects performed two repetitions of stretches held for 20 seconds, and progressed to three repetitions of 30 seconds, five days per week during weeks three and four. At the conclusion of the training session, each group participant was emailed a copy of instructions for the assigned intervention. A weekly reminder email was sent to group members during the 4-week intervention period to encourage corrective exercise program (CEP) adherence. Participants were asked not to begin a new exercise program other than their assigned CEP or alter their current physical activity level during the 4-week intervention period.

Self-Myofascial Release + Stretching + Strengthening (SMRSS) Group. Immediately after baseline posture assessment, SMRSS group members received a 20-minute in-person one-on-one standardized instructional/training session provided by a research team member in the laboratory that included the same SMR + stretching protocol as the SMRS group, as well as incorporated strengthening exercises following NASM recommendations for activation and

integration techniques (Fahmy 2022). Group participants received a 12 x 6 x 6 inch high-density myofascial roller (NASM Tool, Cygnet Systems, Dallas, TX), a 23-inch soft-tissue mobilization tool (Therapist's Choice® Pressure Point Hook Cane, Tampa, FL), a 36 inch medium resistance (resistance = 20 lb.) exercise tube with handles (Stroops, model: Slastix Toner, Clearfield, UT), and a 36-inch medium resistance (resistance = 3.7-5.5 lbs.) exercise band (Theraband, Akron, OH) at no cost to enable implementation of the prescribed 4-week home program. Strengthening exercises included the supine chin tuck (SCT), upper thoracic-lower cervical extension (UTLCE), and a single-arm row with trunk rotation (SARTR). The SCT was performed progressed in three phases: Week 1: chin tuck held 2 seconds, 4 second return to start position, repeated five times. Week 2: same as week 1, but incorporated a towel roll placed behind head to enable increased range of motion during the exercise. Week 3 and 4: chin tuck with head lift 1 inch above the towel roll was held for 2 seconds, 4 second return to start position, repeated five times. The UTLCE exercise was performed by placing the resistive exercise band around the back of the head with neck flexed 15-20 degrees. Participants were instructed to extend their neck to a neutral position against the resistance of the band and hold for 2 seconds, followed by a 4 second return to start position. The SARTR exercise was performed by placing one foot forward; completing a single arm row with exercise tubing using the contralateral arm compared to the lead leg; rotating the trunk 90 degrees toward the side of the body performing the row; followed by reversing these movements to return back to start position in a controlled manner. This exercise was performed on both the right and left sides. The UTLCE and SARTR exercises were performed with 1 set of 10 repetitions for weeks 1-2 and progressed to 2 sets of 10 repetitions in weeks 3-4 (Fahmy 2022). Participants were asked to perform all muscle strengthening exercises three times per week on non-consecutive days throughout the 4-week

intervention period. At the conclusion of the training session, each group participant was emailed a copy of instructions for the assigned intervention. A weekly reminder email was sent to group members during the 4-week intervention period to encourage corrective exercise program (CEP) adherence. Participants were asked not to begin a new exercise program other than their assigned CEP or alter their current physical activity level during the 4-week intervention period.

Control Group (CG). Immediately after baseline CVA assessment, participants randomly assigned to the CG were informed they would not be receiving an intervention and were asked not to begin any new exercise program or alter their current physical activity level over the next four weeks.

Questionnaires and Follow-up Posture Assessment

Two weeks into the study, participants assigned to intervention groups completed a mid-study questionnaire to assess intervention compliance. After the completion of 4-week intervention period, participants in the intervention groups completed a post-study questionnaire to assess intervention compliance and participants in all groups were asked to return to the Biomechanics laboratory to undergo a follow-up posture assessment.

Statistical Analysis

Data were analyzed using IBM SPSS version 28 for Windows (SPSS Inc., Chicago, IL, USA) and reported with mean and standard deviation. Descriptive participant characteristics by group were analyzed with a one-way ANOVA. Paired samples *t*-tests were used to assess within-group differences in means between pre- and post-intervention CVA measures. Between-group comparisons of post-intervention mean CVA change were analyzed with a one-way ANOVA. Levene's test was utilized to assess equality of error variance. Gabriel's test was selected for post-hoc comparisons. The significance level was set at $p < 0.05$.

Results

The trial was completed by 72 participants (51 females, 21 males) with a mean age: 20.17 (SD: ± 2.25 years); mean height: 167.34 (SD: ± 8.25 cm); and mean weight: 70.31 (SD: ± 14.61 kg). All participants reported SOC self-rating ≥ 3/5. Pre-intervention analysis revealed no significant difference ($p > 0.05$) in participant age or anthropometric characteristics between groups. No significant between-group differences ($p > 0.05$) in baseline CVA were present. Within-group comparisons of pre- vs post-intervention CVA outcomes revealed a significantly ($p < 0.05$) greater post-intervention CVA in the PE, SMRS, SMRSS, and CG. Post-hoc comparisons indicated post-intervention mean CVA change in the SMRS group: 3.8 (SD: ± 3.3 deg.); and the SMRSS group: 4.4 (SD: ± 3.1 deg.); was significantly greater ($p < 0.01$) than the CG: 0.8 (SD: ± 1.7 deg.). All participants in the SMRS and SMRSS groups reported intervention adherence as moderately consistent (50-75% sessions performed) or higher on both the mid- and post-study questionnaire. 91% of the PE group reported intervention adherence as moderately consistent (50-75% adherence to guidelines) or higher on the mid-study questionnaire. 96% of the PE group reported intervention adherence as moderately consistent or higher on the post-study questionnaire.

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