Corrective exercises administered online vs at the workplace for pain and function in the office workers with upper crossed syndrome: Randomized controlled trial

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Abstract

Objective

To evaluate the effects of online-supervised versus workplace corrective exercises on neck-shoulder pain (NSP), sick-leave, postural angles, workability, and electromyography (EMG) of interest muscles among the office workers with the upper crossed syndrome (UCS).

Methods

We performed a parallel-group randomized control trial at Shahid Beheshti University (SBU), Tehran, Iran. The office workers (n=36) were randomly assigned to online-supervised, workplace, and control groups (each: n= 12). The two intervention groups completed the exercise program for eight weeks, while the control group continued usual activities. Primary (NSP and sick-leave) and secondary outcomes (forward head posture, round shoulders, and round back angles), workability, EMG (upper, middle, lower trapezius, sternocleidomastoid, and serratus anterior) were measured using visual analog scale (VAS), questionnaire, photogrammetry, and EMG, respectively. All measurements were performed at the baseline and an 8-week follow-up.

Results

In both intervention groups, paired t-tests results demonstrated significant differences in NSP, forward head posture, round shoulders, and round back, respectively. In the online-supervised, workability (physical and mental) improved, and upper trapezius and serratus anterior differed in Max., Ave., activation, offset timing changed in the upper trapezius, respectively. Using ANCOVA, the online-supervised group revealed significant differences, including NSP, postural angles, physical and mental workability, and upper trapezius muscle activation. The sick-leave and other variables were not the cases in all groups.

Conclusion

Online-supervised corrective exercise seems to improve a range of parameters related to work performance. These findings are highly applicable in light of the ongoing COVID pandemic; many workers have to work from home.

Introduction

Some researchers have proposed that prolonged static postures - e.g. sitting in the same forward-leaned position in front of a computer all the day - may cause postural malalignment and be considered as a risk factor for work-related musculoskeletal disorders (WMSDs) (Szeto, Straker et al. 2005). Janda believed

that sustained awkward positions could very likely lead to transformation in the head, shoulder, and spinal curves, causing forward head posture, round shoulders, and round back, anteriorly tilt, and winged scapula (Zad and Patil 2021). Such conditions are postulated to result in constant pressure and degenerative changes in individual's joints and are simultaneously associated with musculoskeletal imbalance and pain (Isper Garbin, Soares et al. 2017). Based on the literature, neck and shoulder impairments, headaches, chronic neck tension, and scapular dyskinesia could negatively influence the workability and typical daily performance (Singla and Veqar 2017). Furthermore, many studies have reported the prevalence rates of approximately 50.5% and 44.8% shoulder and upper back pain among the office workers (Madeleine, Lundager et al. 1999). In 2014, Nejati et al. published a high prevalence of UCS symptoms containing forward head posture, round shoulders, and round back as 61.3, 48.7, and 78.3%, respectively among Iranian office workers (Nejati, Lotfian et al. 2014). However, high-quality research based on prospective cohort studies found no association between the computer use and the risk of chronic neck and shoulder pain (Andersen, Harhoff et al. 2008). Thus, it is why only certain individuals are prone to develop UCS. The previous research have approved that increasing pain intensity regardless of its cause, decreases the workability among sedentary and physical work demands (Bayattork, Jakobsen et al. 2019). Due to musculoskeletal symptoms imposing indirect costs including sick-leave, productivity loss, treatment costs, disability and work absenteeism in office workers, the issues such as lifestyle interventions, identification of the groups at the risk of disability, increased health promotion and early prevention in the workplace could be assumed as great potential for increasing workability and reducing work absenteeism (Sundstrup, Seeberg et al. 2020).

Additionally, UCS is characterized by tightening upper trapezius and sternocleidomastoid following the deep cervical flexors and middle, lower trapezius, and serratus anterior muscles' weakness (Ohlendorf, Erbe et al. 2017). It may cause alteration in scapula muscle activation, movement patterns, and some misalignments in the upper limb that simultaneously contribute to cervicothoracic and glenohumeral joint dysfunction (Seidi, Bayattork et al. 2020). Acting as a bridge between the shoulder and cervical region, the scapula plays a significant role in providing mobility and stability for the neck and shoulders (Cools, Struyf et al. 2014). Previous studies also indicated the relationship between chronic NSP and scapular dyskinesia through altering dynamic scapular stability during the scapular orientation (Cagnie, Struyf et al. 2014). Numerous studies have determined impaired muscle coordination in the neck muscles, cervical pain, and abnormal head position associated with high amounts of EMG activity in the neck flexors' muscles and have highlighted a direct correlation among upper trapezius muscle activity, neck angle, and perceived discomfort during the prolonged computer tasks (Falla, Jull et al. 2004, D'Anna, Schmid et al. 2021). Brandt et al. reported a strong association between perceived NSP intensity and trapezius muscle tenderness among the office workers (Brandt, Sundstrup et al. 2014).

Based on the previous findings, serratus anterior and lower trapezius provide stability for the scapula and maintain the appropriate scapular location to act as an essential shoulder stabilizer and balance the scapular rotation coupling forces (Johnson, Bogduk et al. 1994). Consequently, altered stability of the scapula may create or sustain symptomatic mechanical dysfunction in the cervical spine and influence the neck pain's recurrence (Helgadottir, Kristjansson et al. 2011). Meanwhile, disturbances in scapular

function could be found in both shoulder and neck pain due to the neuromuscular imbalance between the deep phasic and superficial tonic muscles. This phenomenon is worthwhile to be considered for effective management of UCS among the office workers (Page, Frank et al. 2010). In this regard, Cools et al. suggested basic rehabilitation approach, which is focused on the office workers' functional demands, like correcting the function of axioscapular muscles and scapular alignment during the prolonged upper extremities activities (Cools, Struyf et al. 2014). Hence, implementing posture-correction strategies early in the rehabilitation program, performing all interventions in a sitting or standing position with a correct posture, and maintaining an upright body position to retrain a neutral posture, are considered as different techniques for reduction of the chronic neck pain (Falla, Jull et al. 2007).

Although, several studies investigated the efficiency of workplace interventions for rehabilitation or prevention of WMSDs as a global health issue, which influence both employers and employees, an effective intervention is still needs to be warranted (Skamagki, King et al. 2018). Due to lack of research on computer users suffering from UCS, it seems logical to evaluate associated various musculoskeletal symptoms, including forward head posture, round shoulders, and round back along with related muscles' EMG influenced by UCS, and pain in neck and shoulder areas, as well as assessing the extent of workability and sick-leave variables in such populations. Although, most research reported positive effects of supervised and un-supervised interventions in managing WMSDs, some studies underlined that supervised exercise programs are most likely to be beneficial in maintenance and adherence. As a result, they have significantly better influence on diminishing consequential symptoms (Blangsted, Sogaard et al. 2008, Coury, Moreira et al. 2009). Conversely, implementing exercise under supervision can be cost-effective and not always an available workplace resource; however, some individuals prefer to exercise when it fits into their daily working routine (Gram, Andersen et al. 2014). Since many countries worldwide have applied social quarantine during the COVID-19 global pandemic, the office workers were advised to work from home and follow the rules of social distance (Aegerter, Deforth et al. 2021). Nevertheless, evidence-based guidelines for performing home-exercise are lacking. The current study is the first randomized controlled trial with the purpose of comparing the effect of corrective exercises at the worksite versus home under direct supervision during the pandemic.

In more detail, the primary objectives were to assess the effects of an eight-week online-supervised home-based versus workplace-based corrective exercises to decrease NSP and sick-leave. The secondary objectives were to evaluate postural angles (forward head posture, round shoulders, and round back), workability, the surface EMG of interest muscles (upper, middle, lower trapezius, sternocleidomastoid, and serratus anterior) among the computer users working at the offices with UCS.

Methods

Study Design, Participants

A parallel-group randomized controlled trial with testing at baseline and follow-up was approved by Ethics' Committee on the Research at SBU, Tehran, Iran (approval number: IR.SBU.REC.1399.036 /

2020.06.20). The trial was registered at IRCT (IRCT20200729048249N1 / 2020.10.05). The assessments were conducted at baseline and after eight weeks of intervention in the Sport Sciences and Health Laboratory at SBU, Tehran, Iran. The subjects signed an informed consent followed by the Declaration of Helsinki. They were randomly assigned to three groups, the intervention groups (online-supervised and workplace) and the control group. Fig. 1 demonstrates the whole procedure according to CONSORT guidelines in order to ensure the transparent and standardized reporting of the trial. The study protocol has been published, and all detailed procedures have been already described elsewhere (Yaghoubitajani, Gheitani et al. 2021).

The entire study procedure, including assessments, was clarified for 118 volunteers who were invited through invitation letters. Qualified office workers, including 23 females and 13 males, were performed the pre-test and they were all able to meet the eligibility criteria with postural alterations (forward head posture $\geq 45^\circ$, round shoulders $\geq 52^\circ$, round back $\geq 42^\circ$) and pain intensity (≥ 3) in the neck and shoulder areas, measured by photogrammetry and VAS, respectively. Based on the above inclusion criteria, the individuals were excluded from the list of participants if they were pregnant, had a history of joint diseases in the spine, shoulder, pelvis, fracture, and had surgery during the past year, or had a bodyweight out of the normal range ($18 \leq \text{BMI} \leq 25$). The subjects were considered as drop-outs if they missed three sequential sessions or the follow-up test. For their conveniences, the subjects were permitted to leave the study at any stage of the research process.

Study Outcomes, Assessments

The chief researcher measured the study outcomes at the baseline before randomization and after eight weeks. The NSP and sick-leave as the primary outcomes were measured by VAS and questionnaire. The secondary outcomes, including **postural alignment angles** (forward head posture, round shoulders , **and** round back), workability (physical and mental), muscle activation, and timing of the interested muscles (upper, middle, lower trapezius, sternocleidomastoid, and serratus anterior), were assessed by photogrammetry, questionnaire, and EMG, respectively. Demographic data were obtained, including age, weight, height, BMI, smoking behavior, marital status, and education level. The baseline and follow-up test were conducted using assessment methods and testing equipment in the same setting.

Using a 10-cm VAS scale, the subjects rated their NSP intensity, ranging from zero ("no pain") to ten ("worst pain"). The sick-leave was assessed by a single item extracted from evaluation questionnaire of validated outcome. The *response* categories ranged from zero to 31 days, inserting the number of absence working days due to NSP within the past month (Hallman, Holtermann et al. 2019). The photogrammetric method was applied for the postural angles' assessments by identifying anatomical landmarks of the tragus, acromion process of the scapula, spinous process of C-7 and T-12 through removable colored dots to be laterally visible (Karimian, Rahn timer et al. 2019). The workability was evaluated by self-assessing through a single validated item from the workability index questionnaire. The scores range from zero to ten, indicating a cut-off point score of ≤ 7 , implying the poor workability (Gram, Holtermann et al. 2012, Hallman, Holtermann et al. 2019).

The EMG recordings were made through the standard procedure to normalize the recommended range in work-related disorder studies for activation and timing of upper, middle, lower trapezius, sternocleidomastoid, and serratus anterior muscles following careful skin preparation based on SENIAM and previously published guidelines concerning the skin impedance ($\leq 10 \text{ k}\Omega$) and bipolar Ag/AgCl (SKINTACT, Austria) surface electrodes' application (Johnston, Jull et al. 2008). The ME-6000 Megawin (MegaWin, Finland) was used for data collection, and all EMG signals were amplified (gain, 1000), passed through a 10 to 500 Hz band-width filter, and sampled at 1000 Hz processed through the Matlab software (Seidi, Bayattork et al. 2020). The maximal voluntary isometric test (MVIC) was used and normalized the EMG data. After training and a short warm-up, the subjects performed three MVICs holdings for five seconds against the manual static resistance, in which the duration was controlled by a stopwatch. Those subjects who reported pain during the test were excluded to minimize the impact of pain on the assessment consisting of a 30 seconds rest time between each repetition and two minutes for subsequent muscle testing. After five minutes of resting, the subjects performed bilateral arm elevation five times in the scapular plane over concentric, isometric, and eccentric phases, which lasted three seconds as well as three seconds of rest between each phase. After rectifying and smoothing, the root mean square (RMS) was calculated at the time constant of 50 ms for three seconds from the middle of three trials out of five. The RMS mean was divided using MVIC value, was multiplied by 100 to calculate the muscle activity percentage (Arshadi, Ghasemi et al. 2019). The muscle activation onset/offset was calculated based on concentric/eccentric phases from the point that the level of muscle activity reached three standard deviations above/below the rest of the muscle activity and then was analyzed based on the middle deltoid onset/offset timing (De Mey, Danneels et al. 2012).

Randomization

The computer-generated block randomization was performed in a 1:1:1 allocation ratio through the website <https://www.sealedenvelope.com>. The main investigator performed the enrollment, generated the random allocation sequence, and assigned the subjects to the groups. The random allocation sequence was implemented by concealed, sequentially numbered, sealed, and opaque envelopes, through putting a card inside indicating that the allocated group to each subject was randomly executed. A SBU assistant professor supervised all procedures, including the sequence generation process and allocation concealment mechanism to ensure that the assignment schedule was unpredictable.

Intervention

Intervention groups performed eight-week corrective exercises, three times/week, lasting about 50-60 minutes pertaining typical five-minute warm-up and cool-down. Each exercise was individualized based on demographic characteristics, pain intensity, and overload principles. The pain intensity up to five (VAS) was allowed to have ten max. repetition, only if the pain decreased immediately after completing the exercise. The subjects who experienced the higher pain levels, could modify the exercise accordingly.

The online-supervised group performed the program under direct remote supervision in their home environment using desktop videoconferencing software (<https://meet.jit.si/>). To do so, a laptop

monitored by a qualified corrective exercises' expert was utilized to ensure the progress movement pattern and the control load progression. The workplace group who performed the program in their worksite were provided a diary with detailed written and pictorial descriptions. In addition to telephone interviews, expert's weekly presence was accentuated to constantly evaluate the progress, safety, and performance.

The exercise program was prescribed concerning spontaneous postural alterations, muscle activation, movement pattern, and lack of scapula stabilization for the individuals with UCS suffering from NSP. Detailed intervention is available elsewhere (Yaghoubitajani, Gheitasi et al. 2021).

Sample Size and Statistical Analysis

The G*Power software (Version 3.0.10, Germany) was used to calculate the sample size regarding the effect size reported for the corrective exercises compared with the control group without any intervention in a similar study ($n = 33$), however, 12 subjects were assigned in each group in order to avoid potential dropout during the research. The analyses were conducted using IBM SPSS version 20 for Windows (SPSS Inc., Chicago, IL, USA). Variables' distribution were examined by the Shapiro-Wilk ($P \geq 0.05$). Paired t-test and one-way ANCOVA were used for within-group and between-group comparisons. The follow-up values were used as the outcome, while controlling the baseline values. The $M \pm SD$ and the significance levels at $p \leq 0.05$ were applied for data demonstration. The partial η^2 method was utilized to determine the effect size of the differences' magnitude as small ($0.01 \leq \eta^2 < 0.06$), medium ($0.06 \leq \eta^2 < 0.14$) or large ($\eta^2 \geq 0.14$) (Richardson 2011). For the minimum clinically important differences, the formula of ($MCID = SD \times 0.5$) was used (Norman, Sloan et al. 2003).

Results

The assessments were performed among 36 subjects, and the study outcomes were analyzed for the original assigned three groups. Table 1 demonstrates baseline demographic and lifestyle characteristics. All variables had normal distribution based on Shapiro-Wilk test ($P \geq 0.05$). Tables 2 and 3 display within-group and between-group differences, the magnitude effect sizes in study outcomes' improvement at the follow-up, and the MCIDs changes in the intervention groups, respectively.

Table 1
demographic characteristics and lifestyle characteristics: mean $\pm$ Standard deviation (M $\pm$ SD),
and normality distribution

Variable	Group	M $\pm$ SD	t	p	Percent(%)
Age(year)	Control	38.91 $\pm$ 3.87	0.902	0.196	
	Online-supervised	38.58 $\pm$ 7.34	0.941	0.517	
	Workplace	37.00 $\pm$ 8.12	0.923	0.451	
Weigh(kg)	Control	67.18 $\pm$ 13.02	0.878	0.099	
	Online-supervised	66.33 $\pm$ 8.97	0.841	0.059	
	Workplace	67.63 $\pm$ 9.68	0.953	0.746	
Height(m)	Control	1.72 $\pm$ 0.09	0.959	0.756	
	Online-supervised	1.67 $\pm$ 0.08	0.913	0.235	
	Workplace	1.74 $\pm$ 0.07	0.894	0.253	
BMI (kg/m ²)	Control	24.27 $\pm$ 2.91	0.919	0.310	
	Online-supervised	25.86 $\pm$ 1.77	0.919	0.281	
	Workplace	25.90 $\pm$ 1.82	0.936	0.570	
Smoking	Control(Yes/No)				27.3/72.7
	Online-supervised (Yes/No)				0.0/100.0
	Workplace (Yes/No)				25.0/75.0
Marital Status	Control (single/married)				18.2/81.8
	Online-supervised (single/married)				66.7/33.3
	Workplace (single/married)				50.0/50.0
Educational Level	Control (BS, MSc, Ph.D)				45.5/27.3/27.3
	Online-supervised (Diploma, BS, MSc)				16.7/33.3/50.0
	Workplace (Diploma, BS, MSc)				12.5/62.5/25.0

Table 2

Within-group differences (Paired T-Test) in NSP; Sick-leave(SL); Workability (WA)physical/mental; Forward head posture(FHP), Round shoulders(RSH), Round back(RB) angles ; ave./ max. activity, onset/offset of Upper, Middle, Lower trapezius, Serratus anterior, and Sternocleidomastoid(UT,MT,LT,SA,and SCM).

Group	Variable (baseline/ follow-up)	Mean Difference	95% Confidence Interval of the Difference		t	Sig.
			Lower	Upper		
Control	NSP	0.45455	-0.00736	0.91645	2.193	0.053
	SL	0.09091	-0.11165	0.29347	1.000	0.341
	WA.physical	0.27273	-0.25548	0.80093	1.150	0.277
	WA.mental	-0.09091	-0.45326	0.27144	-0.559	0.588
	FHP	0.04545	-0.30539	0.39630	0.289	0.779
	RSH	0.00909	-1.53766	1.55584	0.013	0.990
	RB	-0.23636	-1.48682	1.01409	-0.421	0.683
	UT - ave.	-0.03182	-0.09037	0.02673	-1.211	0.254
	UT - max.	-0.07091	-0.15618	0.01436	-1.853	0.094
	UT - onset	-209.754	-641.00996	221.50087	-1.084	0.304
	UT - offset	-36.5727	-1372.7919	1299.6465	-0.061	0.953
	MT - ave.	-0.08818	-0.17138	-0.00498	-2.362	0.060
	MT - max.	-0.20636	-0.40210	-0.01063	-2.349	0.061
	MT - onse	-238.454	-595.92326	119.01417	-1.486	0.168
	MT - offset	1022.663	-456.49804	2501.8253	1.540	0.154
	LT - ave.	-0.07091	-0.15878	0.01696	-1.798	0.102
	LT - max.	-0.18909	-0.39920	0.02101	-2.005	0.073
	LT - onset	-73.3090	-433.51906	286.90088	-0.453	0.660
	LT - offset	231.5727	-1017.1562	1480.3017	0.413	0.688
	SA - ave.	-0.05818	-0.14805	0.03169	-1.442	0.180
	SA - max.	-0.11364	-0.29595	0.06868	-1.389	0.195
	SA - onset	39.80909	-417.37975	496.99793	0.194	0.850
	SA - offset	312.0454	-558.06528	1182.1561	0.799	0.443
	SCM - ave.	-0.05455	-0.11038	0.00129	-2.177	0.055

	SCM -max.	-0.13545	-0.27971	0.00880	-2.092	0.063
	SCM - onset	317.2636	-621.44766	1255.9749	0.753	0.469
	SCM - offset	139.2818	-1120.7945	1399.3581	0.246	0.810
Online-supervised	NSP	3.91667	2.52310	5.31023	6.186	0.000*
	SL	0.16667	-.08065	.41398	1.483	0.166
	WA.physical	0.16667	-1.00907	1.34240	.312	0.041
	WA.mental	-0.33333	-2.05392	1.38726	-.426	0.038
	FHP	5.62917	4.00022	7.25811	7.606	0.000*
	RSH`	6.40417	3.28478	9.52356	4.519	0.001*
	RB	1.89583	0.16869	3.62298	2.416	0.034*
	UT - ave.	0.09583	0.03523	0.15644	3.480	0.005*
	UT - max.	0.14750	0.05518	0.23982	3.517	0.005*
	UT - onset	-119.333	-468.56510	229.89843	-.752	0.468
	UT - offset	1408.000	242.71548	2573.2845	2.659	0.022*
	MT -ave.	-0.03417	-0.14252	0.07418	-0.694	0.502
	MT - max.	-0.02333	-0.16929	0.12262	-0.352	0.732
	MT - onset	-815.033	-2099.1133	469.04668	-1.397	0.190
	MT -offset	1007.941	-382.80656	2398.6899	1.595	0.139
	LT - ave.	-0.07750	-0.19466	0.03966	-1.456	0.173
	LT - max.	-0.12750	-0.31262	0.05762	-1.516	0.158
	LT - onset	-45.7166	-396.91904	305.48571	-0.287	0.780
	LT - offset	910.8250	16.90960	1804.7404	2.243	0.056
	SA - ave.	-0.13667	-0.24699	-0.02634	-2.726	0.020*
	SA - max.	-0.24250	-0.42903	-0.05597	-2.861	0.015*
	SA - onset	48.42500	-348.15777	445.00777	0.269	0.793
	SA - offset	921.3416	-280.81276	2123.4961	1.687	0.120
	SCM - ave.	0.02167	-0.07419	0.11752	0.497	0.629
	SCM -max.	0.07250	-0.10371	0.24871	0.906	0.385
	SCM - onset	-745.600	-1872.3410	381.14100	-1.456	0.173

	SCM - offset	1053.433	-148.57581	2255.4424	1.929	0.080
Workplace	Nsp	2.50000	1.23606	3.76394	4.677	0.002*
	SL	3.62500	-2.40260	9.65260	1.422	0.198
	WA. physical	0.50000	-1.39592	2.39592	0.624	0.553
	WA.mental	-0.12500	-1.70098	1.45098	-0.188	0.857
	FHP	3.82500	2.36547	5.28453	6.197	0.000*
	RSH	3.30625	.39228	6.22022	2.683	0.031*
	RB	2.77500	.98933	4.56067	3.675	0.008*
	UT - ave.	-0.01250	-0.11766	0.09266	-0.281	0.787
	UT - max.	0.00375	-0.15817	0.16567	0.055	0.958
	UT - onset	-206.287	-592.17509	179.60009	-1.264	0.247
	UT - offset	660.7875	-699.68739	2021.2623	1.149	.288
	MT - ave.	-0.00375	-0.01464	0.00714	-0.814	0.442
	MT - max.	-0.02375	-0.04159	-0.00591	-3.148	0.056
	MT - onset	256.3250	-401.93566	914.58566	0.921	0.388
	MT - offset	25.63750	-817.89258	869.16758	.072	0.945
	LT -ave.	-0.03500	-0.09611	0.02611	-1.354	0.218
	LT -max.	-0.10000	-0.24473	0.04473	-1.634	0.146
	LT-onset	545.0375	-222.28843	1312.3634	1.680	0.137
	LT -offset	-117.875	-1006.7134	770.96349	-0.314	0.763
	SA - ave.	-0.11125	-0.24945	0.02695	-1.903	0.099
	SA - max.	-0.20500	-0.46101	0.05101	-1.893	0.100
	SA - onset	-155.600	-546.49397	235.29397	-.941	0.378
	SA - offset	-252.037	-785.41698	281.34198	-1.117	0.301
	SCM -ave.	-0.01000	-0.18422	0.16422	-0.136	0.896
	SCM -max.	0.03125	-0.27779	0.34029	0.239	0.818
	SCM - onset	-126.712	-1304.8925	1051.4675	-0.254	0.807
	SCM - offset	-180.812	-2010.2942	1648.6692	-0.234	0.822

Table 3

Between-group differences (one-way ANCOVA) in NSP; SL; WA(physical/mental); FHP, RSH, RB angles; ave./ max. activity, onset/offset of UT,MT,LT,SA,and SCM.

Variable	Group	Mean±SD	F	Sig.	Partial Eta Squared	MCID
NSP	Control	4.27±1.34	5.944	0.007*	0.306	0.975
	Online-supervised	3.25±1.95				1.145
	Workplace	4.12±2.29				
SL	Control	1.45±2.73	2.271	0.123	0.144	0.19
	Online-supervised	0.16±0.38				0.37
	Workplace	0.37±0.74				
WA.physical	Control	8.27±.90	0.780	0.048*	0.055	0.67
	Online-supervised	8.00±1.34				1.22
	Workplace	7.00±2.44				
WA.mental	Control	7.63±1.56	1.758	0.042*	0.115	0.72
	Online-supervised	8.50±1.44				1.12
	Workplace	6.25±2.25				
FHP	Control	45.40±.80	26.763	0.000*	0.665	1.25
	Online-supervised	39.97±2.50				0.76
	Workplace	41.51±1.52				
RSH	Control	53.31±2.62	10.046	0.001*	0.427	2.255
	Online-supervised	46.93±4.51				0.865
	Workplace	49.91±1.73				
RB	Control	50.78±3.65	6.400	0.005*	0.322	1.68
	Online-supervised	49.16±3.36				1.63
	Workplace	46.77±3.26				

Variable	Group	Mean±SD	F	Sig.	Partial Eta Squared	MCID
UT - ave.	Control	0.28±0.13	4.289	0.024*	0.241	0.055
	Online-supervised	0.20±0.11				0.075
	Workplace	0.23±0.15				
UT - max.	Control	0.44±0.19	4.808	0.016*	0.263	0.098635
	Online-supervised	0.3333±0.19727				0.10724
	Workplace	0.3600±0.21448				
UT - onset	Control	-134.85±497.30	0.789	0.464	0.055	99.205
	Online-supervised	-134.29±198.41				175.73
	Workplace	85.41±351.46				
UT - offset	Control	329.90±1093.61	2.356	0.114	0.149	851.93
	Online-supervised	-762.35±1703.86				910.015
	Workplace	-1244.95±1820.03				
MT - ave.	Control	0.17±0.14	0.960	0.396	0.066	0.085
	Online-supervised	0.16±0.17				0.035
	Workplace	0.09±0.07				
MT -max.	Control	0.35±0.31	1.933	0.164	0.125	0.105
	Online-supervised	0.25±0.21				0.075
	Workplace	0.17±0.15				
MT - onset	Control	-77.27±307.90	0.797	0.461	0.056	1039.285
	Online-supervised	501.47±2078.57				197.455
	Workplace	66.58±394.91				

Variable	Group	Mean±SD	F	Sig.	Partial Eta Squared	MCID
MT - offset	Control	-346.70±2816.89	1.152	0.331	0.079	1246.94
	Online-supervised	-516.26±2493.89				337.94
	Workplace	-416.51±675.88				
LT -ave.	Control	0.22±0.09	0.314	0.733	0.023	0.09
	Online-supervised	0.25±0.18				0.07
	Workplace	0.18±0.15				
LT -max.	Control	0.45±0.25	0.200	0.820	0.015	0.155
	Online-supervised	0.44±0.31				0.165
	Workplace	0.40±0.33				
LT -onset	Control	-74.22±333.85	0.383	0.685	0.028	277.71
	Online-supervised	-105.75±555.42				320.685
	Workplace	-118.58±641.37				
LT -offset	Control	-101.27±1679.62	0.762	0.477	0.053	790.62
	Online-supervised	-692.82±1581.24				343.74
	Workplace	-235.21±687.48				
SA - ave.	Control	0.34±0.08	0.096	0.908	0.007	0.07
	Online-supervised	0.34±0.14				0.07
	Workplace	0.32±0.14				
SA - max.	Control	0.65±0.18	0.014	0.986	0.001	0.11
	Online-supervised	0.63±0.22				0.13
	Workplace	0.64±0.26				

Variable	Group	Mean±SD	F	Sig.	Partial Eta Squared	MCID
SA - onset	Control	-152.12±497.08	1.701	0.201	0.112	154.65
	Online-supervised	-218.33±309.30				180.39
	Workplace	101.58±360.78				
SA - offset	Control	492.03±873.62	0.885	0.424	0.062	928.275
	Online-supervised	-243.01±1856.55				315.895
	Workplace	210.45±631.79				
SCM -ave.	Control	0.27±0.18	0.490	0.618	0.035	0.11
	Online-supervised	0.29±0.22				0.12
	Workplace	0.34±0.24				
SCM - max.	Control	0.49±0.32	0.820	0.451	0.057	0.155
	Online-supervised	0.46±0.31				0.165
	Workplace	0.48±0.33				
SCM -onset	Control	284.38±716.78	0.383	0.685	0.028	914.44
	Online-supervised	783.87±1828.88				386.195
	Workplace	627.11±772.39				
SCM – offset	Control	-395.87±1322.97	0.708	0.501	0.050	1075.325
	Online-supervised	-1152.22±2150.65				801.995
	Workplace	-712.12±1603.99				

Discussion

The present study found that online-supervised corrective exercises seem to be effective in improving a range of parameters related to work performance. These findings are highly relevant in the light of the ongoing COVID pandemic, where many workers have to work from home.

The findings confirmed that performing eight-week corrective exercises had a significant effect on the NSP among the subjects in the two intervention groups. This is in line with previous findings showing

that corrective exercises improve the neck pain (Mehri, Letafatkar et al. 2020). Many studies reported that prolonged sitting or improper neck and shoulder posture during the work, may have some association with NSP among the office workers (Lee, Lee et al. 2017). Neck pain is associated with the ability to maintain an upright posture, as reported previously, and there could be a relationship among the correction of forward head posture, round shoulders, and pain (Lynch, Thigpen et al. 2010). In this regard, Lee et al. suggested that maintaining an upright body position and implementing posture-correction strategies in different sitting positions, can prevent musculoskeletal pain (Cools, Struyf et al. 2014, Lee, Lee et al. 2017). Hence, all the subjects were initially informed about the UCS consequences; hence, their postural awareness was repeatedly developed throughout the study days and frequent corrections to upright neutral postural position were recommended focusing on the control system in postural re-education programs such as memory joggers, to ensure that those behaviors become kinds of habit (Abdollahzade, Shadmehr et al. 2017).

Further, some researchers recommended the muscle strengthening or endurance exercises for an incorrect posture leading to pain through increased load on the cervical spine and changing the muscle's length (Gram, Holtermann et al. 2012). Meanwhile, training and rehabilitation of power and endurance of the deep neck flexors, have been previously proved to be beneficial for restoring neuromuscular imbalance and cervical stabilization; where, the present study highlighted relevant exercises (Falla, Jull et al. 2007, Lee, Kim et al. 2018). Considering that the scapula plays an important role in NSP and the keystone of the UCS, the current study primarily focused on the function of the scapula muscles to restore and balance the scapula stabilizers. This phenomenon could be due to activating the neck muscles and reducing the compensatory movements of the muscles involved in the area (Cagnie, Struyf et al. 2014, Cools, Struyf et al. 2014, Kang, Im et al. 2021).

Our findings significantly affected the postural angles. Since the alteration in the resting scapular position may occur with the abnormal alignment of cervical and thoracic spine, the forward head posture can result in round shoulders, which may cause enhancing thoracic kyphotic posture, respectively (Kwon, Son et al. 2015). Based on the literature, there might be a relationship among the forward head posture, round shoulders, and round back, with the studies revealing an improvement in response to training programs' exercises (Sheikhhoseini, Shahrbanian et al. 2018). It is supposed that the involved muscles in the UCS may be shortened or lengthened when they are remained in the improper posture for a long time, occurring adaptive lengthening or shortening over the time leading to poor posture. The traditional approach has focused on improving malalignments by stretching the shortened and strengthening the weakened muscles. However, using stretching exercises, some studies reported no changes in the muscle length but indicated improved tolerance to stretching (Sahrmann, Azevedo et al. 2017).

In contrast, the functional approach states that the interactions among all central and peripheral nervous systems, muscular and skeletal structures are the cause of WMSDs (Hamill, van Emmerik et al. 1999). Thus, the initial strategy containing posture, muscle activation, and movement pattern intervention is recommended to be more effective (Hodges, Van Dieën et al. 2019). It seems that focusing simultaneously on the neural and muscular components for improving postural malalignments, brings

about the best results if the intervention is applied at least six weeks with an average of three times a week, and duration of 15 to 60 minutes (Bayattork, Sköld et al. 2020).

The upper trapezius significantly improved in the current study; while, no alterations were found in others (33). The results are to some extent in line with the previous findings of Arshadi and et al., conducted among healthy men with the UCS. In their experiment they reported that an eight-week corrective exercise exhibits significant differences in EMG activity of sternocleidomastoid, upper trapezius, serratus anterior; though, middle and lower trapezius activity revealed no changes (Arshadi, Ghasemi et al. 2019).

Meanwhile, Seidi et al. detected significant differences in middle, lower trapezius, and serratus anterior activation levels performing a comprehensive corrective exercise program by the young males with no pain; nevertheless, the muscle activation timing indicated no specific differences. In the current study, upper trapezius offset timing varied in the online-supervised group (Seidi, Bayattork et al. 2020). Concerning the muscle activation timing, Cools et al. supported the theory that the individuals with pain may have delayed onset of middle and lower trapezius muscle activity, and injured individuals show abnormal muscle recruitment patterns in the same muscles. The timing of muscle activation is an essential factor in coordination with the scapula and arm movement (Cools, Witvrouw et al. 2003).

Due to the presence of a neuromuscular imbalance in the UCS needing sensory-motor function, muscle adaptation to resistance training could happen before the development of hypertrophy, influencing more motor units, learning to use active motor units more effectively, and reducing the inhibitory inputs of alpha motor neurons (Hakkinen 1994).

In our study, the upper trapezius was the only muscle, which displayed activation levels' decrease. This outcome was in line with the findings of the studies that evaluated the upper trapezius activity among the office workers. It is worth noting that the muscle activation can occur by the neural adaptations associated with short-term exercise or may be connected with reduced pain levels rather than a direct result of the exercise program (Villanueva, Rabal-Pelay et al. 2020). In this regard, Andersen et al. described these phenomena in their "wheel of pain reduction" and concluded that specific strength after exercise relieves pain and maximizes the activity, particularly in painful trapezius muscles. Increasing shoulder abduction strength in women with trapezius myalgia and reducing relative workload may indirectly decrease pain (Andersen, Andersen et al. 2009). Consequently, the diminished upper trapezius activation levels prove this issue as the only trapezius muscle part, and often overactivate in the subjects with UCS; so, its lesser activation might lead to pain relief (Kwon, Son et al. 2015).

During this research, the applied intervention improved mental and physical workability in the online-supervised group, which was consistent with the study of Gram et al. However, no statistical differences were found for the sick-leave as a fundamental problem when the individuals are going to work with pain (Gram, Holtermann et al. 2012). Musculoskeletal pain may negatively affect the workability, and physical activity and could make significant differences concerning sedentary behavior, work absenteeism, and workability, which might be associated with NSP (Hallman, Holtermann et al. 2019).

Limitations

Intervention duration in the current study can be considered as a limitation, since UCS influencing scapular muscles' activation may need more time to achieve the appropriate recruitment, timing, and firing rates. Although, postural alignment and pain improvements occur faster, the upper trapezius has started changes. Thus, more comprehensive studies are required to manage the UCS as a sensory-motor disorder due to neuromuscular adaptation. Another limitation of current study was relatively small sample size, which was selected to recruit the subjects in COVID 19 conditions. Although, the study had sufficient statistical capability to show clear differences between corrective exercises and the control conditions, it was not enough powerful to compare the two active interventions. However, the main finding of the present study – i.e. that online-supervised corrective exercises are effective – remains relevant to similar types of subjects with UCS. Eventually, lack of blinding in the study design could be assumed as another unachievable limitation with the exercise interventions.

Conclusion

Implementing an eight-week corrective exercises' program resulted in clinically desired significant improvements in most study outcomes. The findings in the online supervised group revealed significant changes, which confirm that the supervised intervention could be more effective than un-supervised intervention. However, it seems very difficult to compare the consequences of the current study with those of others. The reason is that previous research with similar titles, evaluated the effects of various exercises on different study populations with different outcome measures, which make it difficult to interpret the results. In the present study, the magnitude of the effect sizes in intervention groups, indicated that prescribed corrective exercises, positively affect NSP, forward head posture, round shoulders, round back, workability and restored upper trapezius muscle activity. Based on the findings, it is suggested to perform the training under direct supervision rather than alone and without any supervision. Further, WMSDs impose indirect costs, including productivity loss, treatment costs, and disability. Hence, managing the UCS is highly recommended among the office workers, particularly the computer users with NSP in order to increase health condition and early prevention in the workplace, which in turn could significantly increase the workability. However, it is worth mentioning that nothing is worthwhile to see the individuals work hard but always experience pain.

Declarations

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Competing Interests

Authors Zohreh Yaghoubitajani(ZY), Mehdi Gheitasi(MG), Mohammad Bayattork(MB), and Lars Louis Andersen(LLA) declare that they *have no relevant financial or non-financial interests to disclose*.

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Authors Contributions

ZY and MG *contributed to the study conception and design*. ZY performed clinical examination and data collection. MG and MB participated in the methodologically development and design of the statistical analysis. ZY *wrote the first draft of the manuscript*. LLA contributed to the comments and suggestions that greatly improved the manuscript. Finally, all the authors revised it critically for important intellectual content, agreed with the content, contributed to the current study's refinement, and approved the final manuscript.

Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request. The researchers interested in using the final dataset for scientific purposes may contact the corresponding author.

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by Ethics Committee on the Research at SBU, Tehran, Iran (approval number: IR.SBU.REC.1399.036 / 2020.06.20)

Consent to publish

Not applicable

Conflict of interest

Authors Zohreh Yaghoubitajani(ZY), Mehdi Gheitasi(MG), Mohammad Bayattork(MB), and Lars Louis Andersen(LLA) declare that they have no conflict of interest.

Informed consent

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all the *individual* subjects for being included in the study.

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Figures

Figure 1

Study flowchart

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