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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2018 15(4): 3708-3717. **OPEN ACCESS**

The effect of cranio-cervical flexion training and rest breaks on neck pain and functional performance in visual display unit users

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Sustained sitting posture is attributed to the high prevalence of neck pain in office workers with computer-based tasks. Purpose: To investigate the effect of cranio-cervical flexion training (CCFT) and supplemental rest breaks on the ability of Visual Display Unit (VDU) users on the accuracy of work. 24 computer users randomly assigned into 2 groups ("A" control & "B" study). Both groups received a lecture on proper posture during work, assessment and modification of workstation set up but only group "B" received CCFT and supplementary rest breaks daily for of six weeks. Pain intensity, functional neck disability, and work habitual posture were measured and compare between before and after intervention using Visual Analogue Scale, Neck Disability Index, and Digital Imaging for Postural Assessment method (DIPA), respectively. Both groups showed intergroup difference in all the measured parameters, except for Gaze angle in group A showed non-significant difference. Between group comparisons showed significant difference in VAS and CCFT in favor of group B. For neck angles there was significant difference in favor of group B except for neck flexion and Gaze angles and same was noted in Neck Disability Index. The study revealed that 6 weeks of repeated micro rest breaks and deep cervical training improves cervical angles and deep flexors strength thus enhance neck postural control. This exercise could be used as preventive measure against the development of neck dysfunctions in risk population.

Keywords: Mechanical neck pain; Neck exercises; functional performance; VDU users; Rest breaks.

INTRODUCTION

Work- related musculoskeletal disorders (WRMSDs) of shoulder; wrist, Neck and/or back have many causes. Some cases are caused by acute trauma or by any systemic disease. Among computer office workers, WRMSDs is caused by chronic cumulative micro traumas, which may result in severe symptoms as pain, numbness and tingling sensation (Ranasinghe et al., 2011).

These symptoms lead to reduction of worker productivity, difficulty to perform job tasks and high treatment costs. Work-related physical factors, psychosocial factors and lack of awareness were all important associations to reduce WRMSDs. There is a great need to apply effective preventive strategies to overcome these problems in the sake of improvements in performance (Hutting et al., 2014 and Van Niekrek et al.,2008).

Sustained sitting postures and the related load on the cervical spine can be considered as important contributors to the high prevalence of neck pain in office workers and individuals performing computer-based tasks. (Cote et al., 2008).The computer work typically results in low-level static loading of back, shoulder and neck muscles, this results in continuous activation of small motor units at a relatively high level of activation. Those subjects who are exposed to relatively high levels of muscle activation and relatively few instants of relaxation during a low-intensity task, will have an increased risk of developing myalgia at the trapezius muscle (Visser B, 2006).

The WRMSDs usually associated with improper computer workstation setup, so Training programs to provide employees with the necessary ergonomics knowledge and skills regarding proper workstation setup may be effective in reducing and preventing musculoskeletal symptoms and injuries (Lewis et al., 2002).

The effect of **c**hanging the whole body sitting posture and its influence on head and neck posture and levels of activity in the neck flexor and extensor muscles were investigated (Falla et al., 2007). Flexed head and neck postures are associated with an increase in gravitational load moment and cervical extensor muscle activity. This may contribute to the higher prevalence of neck pain in individuals with this flexed head and neck postural habit during seated work (Choi, 2003).

Physical factors, such as repetitive movements, awkward posture and unorganized workstation design, are not the solely risk factor for the development of WRMSDs, also there is psychosocial factors such as low social support and high job demands (Hutting et al., 2014).

It has also been suggested that musculoskeletal symptoms in general and neck shoulder symptoms in particular induce & computer worke productivity loss in(Kang et). al, 2012

Workstation redesign and administrative interventions are recommended modifications, such as training and correcting posture. This can be done by postural exercises which encourage the upright posture that tends to decrease cervical extensor activity and increase activation of the deep flexor muscles. Furthermore a personalized preventive workstation intervention can improve spinal work-related posture and musculoskeletal symptoms for workers who use visual display units (VDUs) (Pillastrini et al., 2007).

EMG, VAS and NDI were used to note that specific training of the deep cervical flexor muscles in women with chronic neck pain reduces pain and improves the activation of these muscles, especially in those with the least activation of their deep cervical flexors before training (Falla et al., 2012).

The (CCFT) is a valid method as evident by strong linear relationship between the amplitude of (DCF) muscles and the 5 incremental stages of (CCFT), measured in asymptomatic participants with forward head posture. It should be emphasized that such relationship was not evident for the activity in the superficial cervical flexors (Sternocleidomastoid (SCM) and Anterior Scalene (AS)), whose activation only increased significantly in the latter more challenging phases of the test starting from 3rd stage (Falla et al., 2003). Also, the reliability of the (CCFT) has been studied by different research groups and has shown that this test possesses a high intra-tester reliability of 0.9 as well as a reasonable agreement, thus indicating very high reliability (Hudswell et al., 2005).

There is no substantial evidence for posture changing over a working day was found and the precise relationship between discomfort and posture requires further investigation. (Szeto et al., 2002). ***,So***the current study investigated the effect of applying multi factorial approach in terms of deep cranio-cervical flexors exercise training program (CCFT) and supplemental rest breaks for VDUs users on their neck discomfort, functional ability and angles.

MATERIALS AND METHODS

Participants:

Twenty Four female participants were recruited in this study from Wadi Elneel Hospital. All subjects were regular computer users and they were assigned randomly into two groups. Control group (A) received a lecture on proper posture during work, assessment and modification of workstation set up, while study group (B) received same as group A in addition to deep cranio-cervical flexors exercise training (CCFT) and supplementary rest breaks daily for of six weeks program. The aim and the procedures of the study were explained to each participant and an informed consent was obtained prior to intervention. The study was approved by the Institutional Ethics Committee of the Faculty of Physical Therapy, Cairo University, Egypt (No:P.T.REC/102/00735).

Inclusion criteria were scoring on VAS < 6 and on Neck Disability Index (NDI) <15), age ranged from 21-35 years old and body mass index (BMI) ≤ 30 Kg/ m^2. Furthermore, subject should be working in a computer setup for 6 hours per day, 5 days / week for not less than one year. Participants should have normal visual acuity or wears proper vision correction eye glasses.

For exclusion criteria, any subject with history of cervical or upper limb pain and fixed or mobile spinal deformity was excluded from the study. Also, it was excluded subjects with history of neuromuscular disorders or surgery of the upper quadrant of the body, Temporo-mandibular joint dysfunction or uncorrected impaired vision or audition. Lastly, uninvestigated recurrent headaches and vertebra-basilar insufficiency were excluded.

Instrumentations:

Digital Camera:

A 14 megapixels Kodak digital camera, AF 4X Optical Aspheric, Lens 27mm-108 mm (add manufacturer and country) was used in the study to capture participant's posture while working on a task pre and post study. Digital Imaging for Postural Assessment (DIPA) method has a reported excellent intra-rater reliability (ICC = 0.98 - 0.99) and inter-rater reliability (ICC = 0.91- 0.99) in measuring cervical angles (Lau et al., 2009). AutoCAD Software version 19: The software was used to analyze digital photos to measure the neck and head angles. This software has been used previously in cervical angles analysis (Letafatkar et al., 2011).

Pressure Biofeedback Unit (PBU):

The PBU (MAC Group, Inc., Japan) was used during deep cranio-cervical flexion (CCF) test and training as a visual biofeedback instrument for the study group. They were instructed to press by his occiput (back of the head) on the air filled unit with starting point of 20 mmHg up to each participant's limit. It consists of a non-elastic 3-chambered pneumatic bag (16.7×24 cm), a catheter and a manometer gauge ranging from 0-300 mmHg with an accuracy of ±3 mmHg Fig. 1.

Visual analogue scale (VAS):

All participants were asked to mark their current neck pain level on a scale ranged from (0-10) as (0) represents no pain and (10) represents the worst pain ever.

Neck disability index (NDI):

The NDI used to measure the consequent effects of neck pain on participants' disability. Subjects with score ≤ 15 were recruited in this study to be in line with the previous studies which investigated the motor control deficits in subjects with work-related neck pain (Falla et al., 2003 and Ylinen et al., 2003).

Workstation Ergonomics Self-assessment checklist:

It was developed by organizational health sector, department of education, training and employment to reduce computer work-related hazards and promote safe working environment. The checklist categorized 24 items covering all areas of a computer workstation setup in categories (the office chair, keyboard & mouse, work surface, breaks, accessories, and laptop), in which the user checks her current workstation for Yes/No or NA; with a suggested action to each point as pre-intervention **(**Landsbergis, 2010).

Procedures:

Assessment procedures

All the assessments were applied before intervention and after 6 weeks of intervention in both groups.

Measurement of neck angles:

Adhesive markers were placed at the three anatomical points (Canthus of the eye, Targus, C_7), then; Subjects were asked to assume their habitual posture while focusing on the center of the computer monitor screen during the image capturing. While they were distracted by an everyday work tasks to capture images, the camera was mounted on a tripod stand, fixed at a standardized distance of 200cm from the subject's lateral foot, using electronic angle finder to insure that camera at vertical level. The tripod height was adjustable so that the camera would be at the same level of C7 spinous process (Silva et al., 2009).

Repeated captures were taken to overcome the subject's tension during image capturing as well as to overcome the difference between measurements because of postural swaying. The subjects were instructed to flex and extend the neck several times to restore resting head posture(Verma et al., 2012).

Sagittal plane photos were used to measure head flexion (HF), neck flexion (NF), cranio-cervical flexion (CCF) and gaze angle (GA) using the AutoCAD software version 19. The three photos were analyzed, and an average was calculated and used for further statistical analyses**.**

2-Assess the subject's neck pain on the VAS and NDI then each participant filled the Workstation Ergonomics Self-assessment checklist**.**

3-The CCF test is a clinical test of neuromotor control of the deep flexors of the cervical spine. It was performed with the subject supine with a PBU placed sub-occipital. The starting PBU pressure is 20 mmHg while the subject applied a gentle head-nodding action of deep cranio-cervical flexors for 5 incremental stages of increasing range. Each stage was being held for 10 seconds (Falla et al., 2003). The physiotherapist identified the target level to start the intervention in group B when the patient could hold steadily for 5 s without resorting to retraction, without dominant use of the superficial neck flexor muscles, and without a quick, jerky cranio-cervical flexion movement. Performance was guided by feedback from PBU to monitor the flattening of the cervical lordosis that results from the contraction of the deep neck flexors, observation should be made to avoid the sternocleidomastoid and anterior scalene compensation (Mayoux-Benhamou et al., 1997 and Mayoux-Benhamou et al., 1994). The linear relationship between the incremental pressure targets of the CCFT and the cranio-cervical flexion range of motion has been demonstrated by (Falla et al., 2003).

The performance index measure of the CCFT is the highest level of pressure the individual could hold for 10 seconds up to a maximum value of 30 mmHg. The intra- and inter-reliability for the CCFT was between "fair to good" and "good to excellent" (ICC: 0.63 to 0.86) with satisfactory construct validity demonstrated (Juul et al., 2013 and Jørgensen et al., 2014).

Computer workstation modification:

It was applied for both groups A and B. The chair was easily adjustable to support lower back properly, and allow up/down movements for proper height in relation to keyboard position, seat tilt forward/backward. The keyboard was detachable to permit flexible positioning. A wrist rest was available for those who desire it to keep the wrist level straight and in a relaxed position. The Visual Display Terminal monitor (VDT) was positioned so that the distance from the eyes to the screen can be adjusted, allowing the center of the screen to be positioned so viewing angle is 15˚ to 25˚ below eye level at 130˚ backward tilt. Monitor screen glare reduction was achieved by orienting VDT so that the user did not face an unshielded window or a bright light source (Straker et al., 2008).

Deep cranio-cervical flexors CFF training:

The subjects in group B followed the protocol of Jull et al., 2008 as each subject gently and slowly nod the head as if saying "yes" so that so the pressure sensor either measures 2 mmHg 4mmHg, 6mmHg, 8mmHg, or 10mmHg while the increment is progressed to the next level without rests in between (the pressure sensor should read 30mmHg at the end of the movement sequence) as presented in figure 2. For each target level, the contraction duration was increased to 10 s, and the subject trained to perform 10 repetitions with brief rest periods between each contraction (~3–5 s).Once one set of 10 repetitions of 10 s was achieved at one target level, the exercise was progressed to train at the next target level up to the final target of 10 repetitions of 10 s at 30 mmHg. Repeat the highest level achieved with correct form until a total of 10 reps with 10 second holds are achieved. The participant should practice the exercise at least twice daily.

Performance Index Measure:

Record the number of times the patient can hold the pressure level. Multiply that by the pressure increment. For example, if the patient was able to achieve 4mmHg without breaking form and could perform 6 reps of 10 second holds without breaking form, the performance index would be 24. The highest performance index possible is 100 (10mmHg x 10 reps). (Jull et al., 2008).

The exercise regime was conducted over a 6-week period and CCFT group (B) subjects received personal instructions and supervision once per week for the duration of the study. Subjects were asked not to receive any other specific intervention for their neck pain. The exercise was performed without any provocation of neck pain.

Statistical analysis:

Descriptive statistics are presented as means and SD for all participants. The main outcome measures of this study were neck discomfort, CCFT and habitual postural control (cervical angles head flexion, neck flexion, cranio-cervical flexion and gaze angles) as quantified by the VAS, NDI results, CCF test results and cervical angles measurements respectively. Between groups comparison of VAS and NDI were analyzed by WILCOXON test that is used for numeric scales with small sample size and lack of normality in the results. While CCF training outcome and cervical angles were done using paired t-test. With the p-value set at< 0.05.

RESULTS

Out of thirty six patients, 24 students were completed the study and their data were used for the statistical analysis. For the demographic characteristics in both groups showed no significant (P> 0.05) differences as demonstrated in table 1.

Within groups comparisons, VAS in group A showed only 0.75 points decrease on the scale while group B decreased by 2.83 points and this reflected on the percentage of improvement which was observed in both groups as 28.57% and 43.8% respectively. For the NDI the same observation was noted as group A improved their neck functional ability by 3.7% in comparison to group B which showed significant improvement by 57.5% as shown in table 2.

Furthermore, both groups showed significant (P< 0.05) difference in all the measured neck angles except for group A which showed no significant difference (P> 0.05) for the Gaze angle. Regarding the CCFT, it showed significant increase in the pressure excreted by the participants with improvement 9.15 and 34.6% in group A and B respectively as presented in table 3.

Comparing the mean values between the both groups:

Between group comparisons, for the VAS showed no significant (P=0.13) difference in pre-intervention while showed significant (P= 0.0001) difference in post intervention in favor to group B. regarding the NDI, pre and post intervention comparisons showed no significant (P= 0.23 & P= 0.11) differences respectively as shown in table 4.

In addition, pre-intervention comparisons between groups for HF, NF, CCF and Gaze angles showed no significant (P= 0.332, 0.068, 0.078, 0.087) differences respectively. Post intervention comparisons showed significant (P= 0.013, 0.0001, 0.0001) differences for the HF, CCF angles respectively, while no significant (P= 0.34, 0.11) differences were observed for NF and Gaze angles respectively, table 5.

Unpaired t-test was used when comparing the CCFT between two groups “A” & “B” before intervention and no significant difference (p> 0.05) was revealed, as the pre-intervention value is fixed (20 mmHg) in the two groups as demonstrated in figure 3. While post intervention comparison showed significant difference (P=0.0001) between the two groups as shown in table 6.

Fig.1: The Pressure Biofeedback Unit PBU (MAC Group, Inc., Japan).

Table 1: Demographic characteristics of both groups.

Variable	Groups	Mean ± SD	p-value
Age (years)	Group A	27 ± 3.17	0.443
	Group B	30.4 ± 5.48	
Weight (Kg)	Group A	76.58 ± 7.87	0.311
	Group B	72.92 ± 12.31	
Height (cm)	Group A	171.25 ± 6.06	0.309
	Group B	169.5 ± 7.26	

Fig. 2: The clinical application of the craniocervical flexion test CCFT.

BMI	Group A	26.02 ± 2.72	0.099

Table 2: Comparison between pre and post mean values in both groups for VAS and NDI.

Variables	G A	G B	z-value	p-value				
	pre	Post	Pre	Post	G A	G B	G A	G B
VAS	4.5 (± 0.9)	3.75 (± 1.66)	4.25(± 1.14)	1.42 (± 0.9)	3.998	3.116	0.0001*	0.0001*
NDI	7.17 (± 2.89)	7.42 (± 2.02)	8.33 (± 2.46)	3.58 (± 1.93)	0.3138	16.998	0.37828	0.0001*

G A: group A G B: group B P ≤ 0.05= significant* VAS: visual analogue scale NDI: neck disability index

Table 3: Comparison between pre and post mean values in both groups for flexion angles and cranio-cervical training.

Variables	Mean ± SDG A		Mean ± SD G B		% of improvement		t-value		p-value	
	pre	Post	Pre	Post	G A	G B	G A	G B	G A	G B
HF angle	89.3 ± 8.56	67.8 ± 17.5	91.03 ± 14.6	71.2 ± 13.5	24.11%	26.10%	4.115	4.098	0.0001	0.0001
NF angle	60.4 ± 5.78	48.9 ± 10	70.6 ± 17.3	45.6 ± 7.52	18.90%	36.95%	16.998	14.322	0.0001	0.0001
CCF angle	151.8 ± 3.87	152.2 ± 4.99	159.5 ± 7.66	154.3 ± 10.20	3.65%	11.65%	3.467	5.443	0.0001	0.0001
Gaze angle	22.05 ± 4.6	22.05 ±4.23	25.14 ± 6.89	23.47 ± 4.9	0.00%	8.89%	0.022	3.098	0.996*	0.015
CCFT	20 ±0	21.83 ±0.94	20 ± 0	26.92 ±1.73	9.15%	34.6%	6.7747	13.8508	0.019	0.047

* non-significance HF: head flexion NF: neck flexion CCF: cranio-cervical flexion CCFT: cranio-cervical flexion training

Table 4: Mean difference pre post values comparisons between both groups for VAS and NDI.

Variables	Mean ± SD			Mean ± SD			Mann-Whitney U-value	
	Pre A	Pre B	MD	Post A	Post B	MD	pre	post
VAS	4.5 ±0.9	4.25 ± 1.14	0.25	3.75 ±1.66	1.42 ±0.9	2.33	164.7	96.4*
NDI	7.17 ±2.89	8.33 ± 2.46	1.16	7.42 ± 2.02	3.58 ±1.93	3.84	175.5	125.6

±SD: standard deviation P ≤ 0.05= significant* VAS: visual analogue scale NDI: neck disability index

Table 5: Pre and post values comparisons between both groups for HF, NF, CCF and Gaze angles and CCFT.

Variables	Mean ± SD		Mean ± SD		T-value		p-value	
	Pre A	Pre B	Post A	Post B	pre	post	pre	post
HF angle	89.3 ± 8.56	91.03 ±14.6	67.8± 17.5	71.2 ±13.5	1.649	3.778	0.332	0.013*
NF angle	60.4 ± 5.78	70.6 ± 17.3	48.9 ± 10	45.6 ±7.52	2.119	1.104	0.068	0.344
CCF angle	151.8 ± 3.87	159.5 ±7.66	152.2 ± 2.15	154.3 ± 10.20	2.098	4.778	0.078	0.0001*
Gaze angle	22.05 ± 4.6	25.14 ±3.89	22.05 ± 4.23	23.47 ±4.9	1.779	1.324	0.087	0.112

HF: head flexion angle NF: neck flexion angle CCF: cranio-cervical flexion angle CCFT: cranio- cervical flexion training P ≤ 0.05= significant*

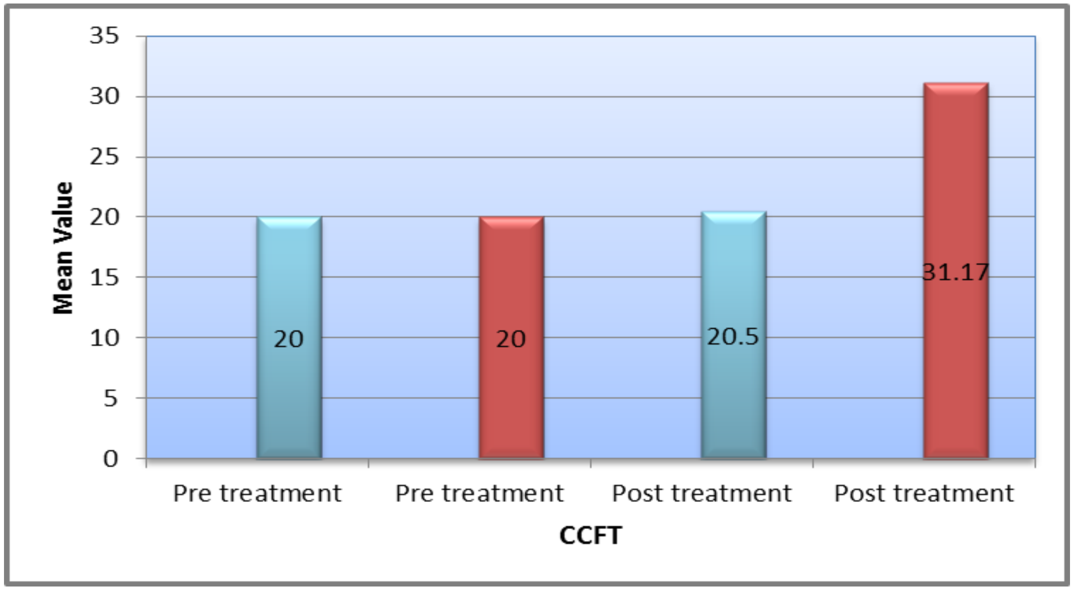

Figure. 3: Pre and post intervention mean values of *CCFT* between both groups.

Table 6: CCFT post- intervention mean values comparison between both groups.

Two Groups	CCFT	
	Post - Intervention A	Post - Intervention B
Mean ± SD	20.5 ± 0.67	31.17 ± 1.64
MD	20.5	29
t-value	20.8142	
p-value	0.0001	
Level of sign.	S	

DISCUSSION

The current study aimed to shed light on the effect of deep CCF exercise and supplemental rest breaks on neck discomfort and functional performance (work accuracy) in computer users, trying to detect an appropriate intervention to avoid or minimize neck pain without affecting productivity. Results of this study illustrated that low load CCFT combined with workstation modification training and micro rest breaks decrease neck discomfort level, functional neck disability level and increase deep cervical flexors muscles performance thus improve automatic static postural control during work in computer users. This exercise could be used as preventive measure against the development of neck dysfunctions in risk population.

The results of this study agree with (Falla et al.,2004) who indicates altered voluntary and automatic function of the DCF muscles and is suggestive of an impaired capacity of the DCF muscles to support the cervical spine in individuals with neck pain.

In agreement with (Falla et al., 2007) who concluded that decreased endurance of the cranio-cervical flexor muscles has been observed in patients with neck pain at 20% of their maximal voluntary contraction. Other factors to poor head position awareness may be attributed to reduced proprioception. In his study, following a 6-week intervention with either cranio-cervical flexor training or neck flexor endurance-strength training, they found only the group that received the specific cranio-cervical flexor training improved their ability to maintain an upright position of the cervical spine.

This study 'findings are also consistent with (Chiu et al., 2005) who compared the performance of the DCF muscles on the CCFT in individuals with and without chronic neck pain. Those with chronic neck pain had significantly poorer performance on the CCFT (mean pressure achieved, 24 mmHg when starting at 20 mmHg) when compared with those in the asymptomatic group (mean pressure achieved, 28 mmHg when starting at 20 mmHg).

In regard to changes in pain and perceived disability, the findings of the current study were consistent with those of (Falla et al., 2007**)** who found a significant reduction in average intensity of pain (VAS) and perceived disability (NDI) in both groups in favor to the cranio-cervical flexor training group which showed a significant improvement in the ability to maintain an upright position of the cervical spine.

The present findings are supported by the results of (Stupar et al., 2008) who found that work related musculoskeletal disorders and occupational safety are compromised by static posture at end-joint ranges of motion, concluded that ergonomic training workshops have significantly improved the participants' knowledge of ergonomics through utilizing their enhanced skills to improve the occupational safety and reduce losses caused by work related musculoskeletal disorders, thus achieving the long-term objective of the workshop and ergonomics rule. They also recommended the introducing new tasks that vary the postures and movements are required to prevent these complications.

Our results agreed with Sommerich et al.,2001 who concluded that optimal overall workstation setup is that "which meets the needs of the individual user" suggesting a need for employee training in ergonomics which includes recognition of individual responses to visual and musculoskeletal stressors, meaning easy adjustment of work stations and training in workstation adjustment to meet individual needs**.** Also, they demonstrate that appropriately designed and supervised exercise program and ergonomically modified workstation may be more efficient than rest breaks alone in decreasing discomfort and fatigue levels in computer data entry users.

The main limitations of the reviewed research were the difficulty to isolate the effect of breaks from exercise, and the comparison of exercise and non-exercise groups did not always show a significant difference. Also, the exercises were not performed every day under supervision during the research and participants in the non-exercise groups walked during their breaks which may have affected the study results.

Limitation

The number of subjects in the current study was limited and we did not formerly use the statistical power of analysis. Based on this limitation, the current study could be considered a preliminary helpful study for future research.

CONCLUSION

From the results of the present study, it can be concluded that low load CCFT combined with workstation modification training and micro rest breaks decreased neck pain, perceived functional neck disability and increased deep cervical flexors muscles strength thus improved automatic static postural control during work without compromising workers' productivity in computer users.

CONFLICT OF INTEREST

The authors have no conflict of interest to report.

ACKNOWLEGEMENT

Authors would like all subjects who participated in this study.

AUTHOR CONTRIBUTIONS

KHB and NAA designed and conducted research. DMK and SAT collected the data and undertook statistical analysis. KHB, NAA and SAT wrote the manuscript. DMK revised and edited the manuscript. All authors contributed toward data analysis, drafting and critically revising the paper, gave final approval of the version to be published.

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